



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

# JWST NIRSpec MOS Observation Planning in APT

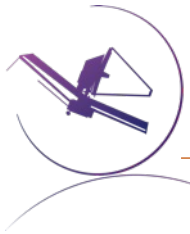
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Dan Coe

ESA/AURA Astronomer

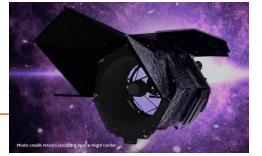
NIRSpec Instrument Scientist

since 2024



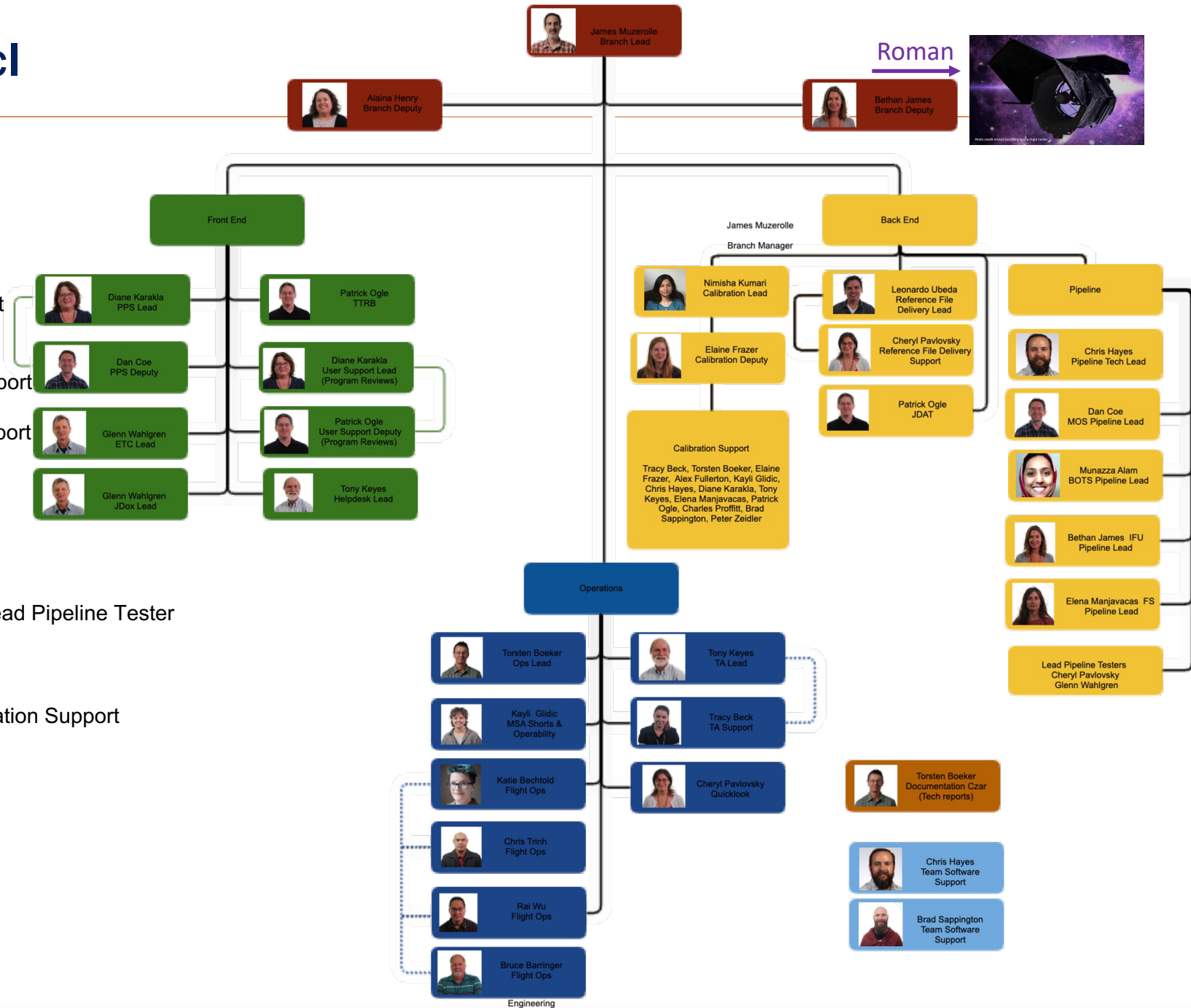
# NIRSpec team @ STScI

Roman →



## NIRSpec (Feb 2024)

- **James Muzerolle:** Branch Lead, Branch Manager
- **Alaina Henry:** Branch Deputy
- **Bethan James:** Branch Deputy, IFU Pipeline Lead → Roman
- **Diane Karakla:** PPS Lead, User Support Lead, Calibration Support
- **Dan Coe:** PPS Deputy, MOS Pipeline Lead
- **Glenn Wahlgren:** ETC Lead, JDox Lead, Lead Pipeline Tester
- **Patrick Ogle:** TTRB, User Support Deputy, JDAT, Calibration Support
- **Tony Keyes:** Helpdesk Lead, TA Lead, Calibration Support
- **Torsten Boeker:** Ops Lead, Documentation Czar, Calibration Support
- **Kayli Glidic:** MSA Shorts & Operability, Calibration Support
- **Katie Bechtold:** Flight Ops
- **Chris Trinh:** Flight Ops
- **Rai Wu:** Flight Ops
- **Bruce Barringer:** Flight Ops
- **Tracy Beck:** TA Support, Calibration Support
- **Cheryl Pavlovsky:** Quicklook, Reference File Delivery Support, Lead Pipeline Tester
- **Nimisha Kumari:** Calibration Lead
- **Elaine Frazer:** Calibration Deputy, Calibration Support
- **Leonardo Ubeda:** Reference File Delivery Lead
- **Chris Hayes:** Pipeline Tech Lead, Team Software Support, Calibration Support
- **Munazza Alam:** BOTS Pipeline Lead
- **Elena Manjavacas:** FS Pipeline Lead, Calibration Support
- **Brad Sappington:** Team Software Support, Calibration Support
- **Alex Fullerton:** Calibration Support
- **Charles Proffitt:** Calibration Support
- **Peter Zeidler:** Calibration Support





JWST Cycle 5 is ~ half NIRSpec. ~Half of that is MOS.

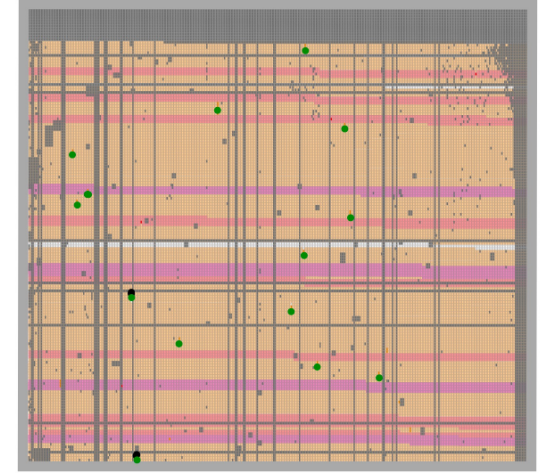
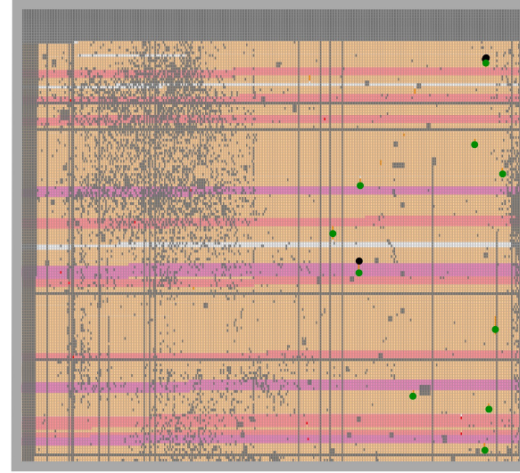
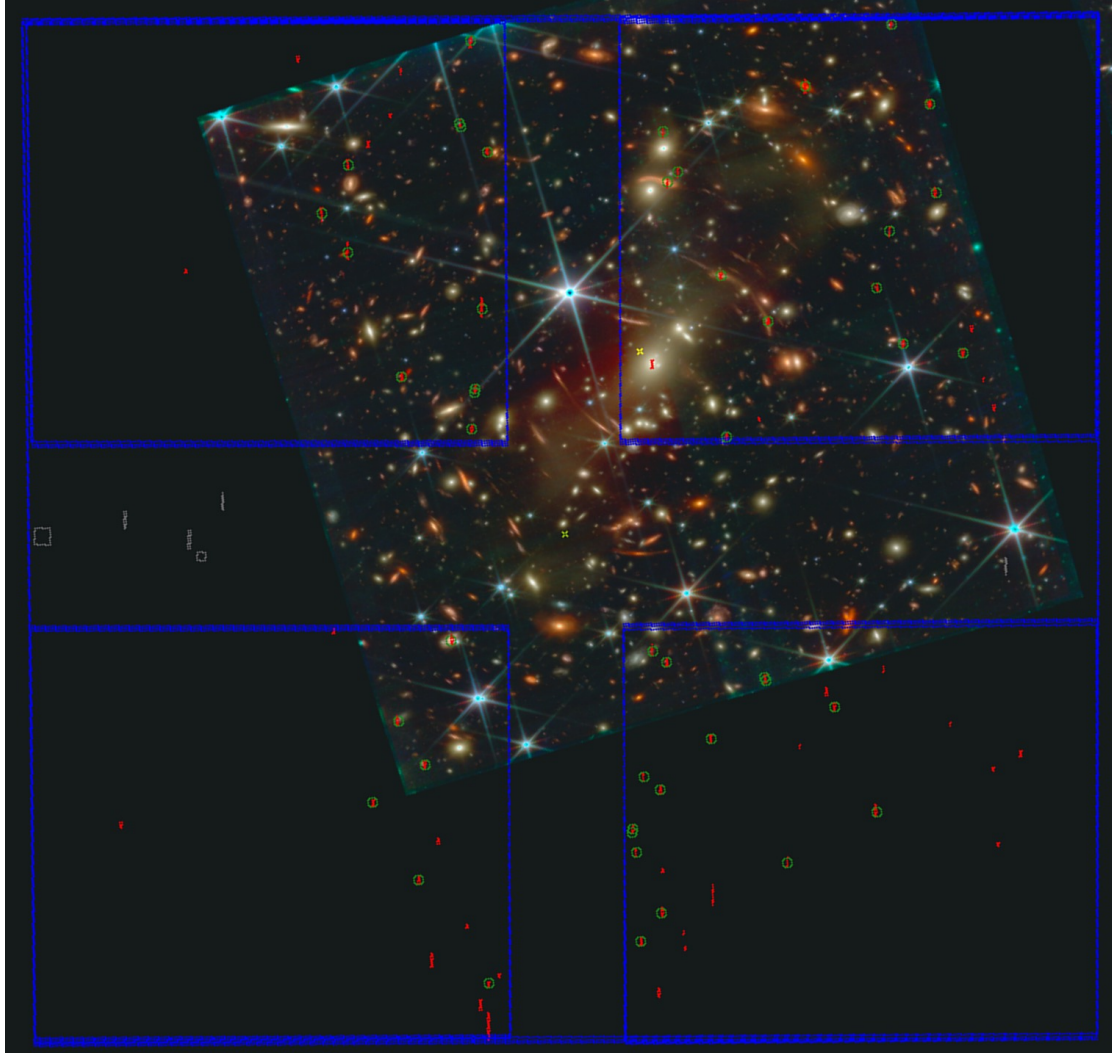
JWebbinars #30, #33



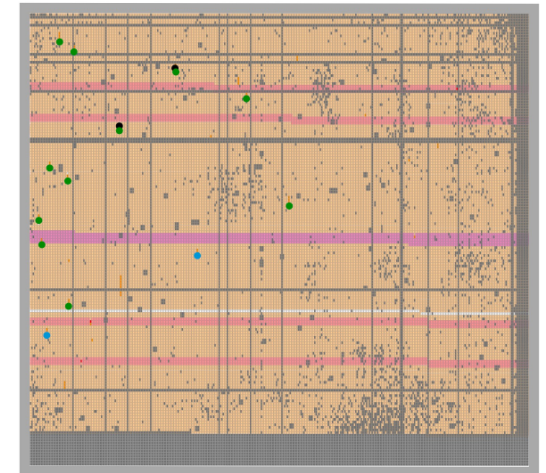
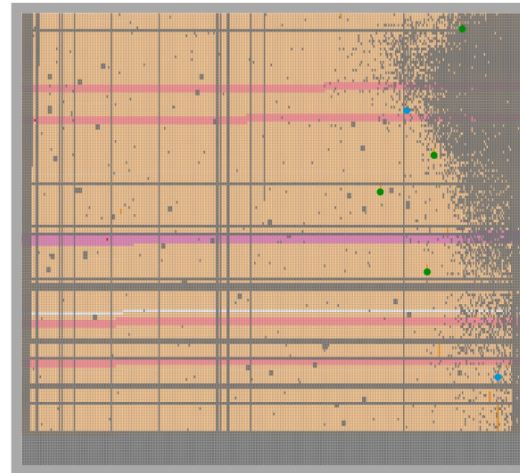
# NIRSpec MOS Observation Planning in APT w/ MPT

Diane Karakla  
Dan Coe, Kayli Glidic

APT Aladin



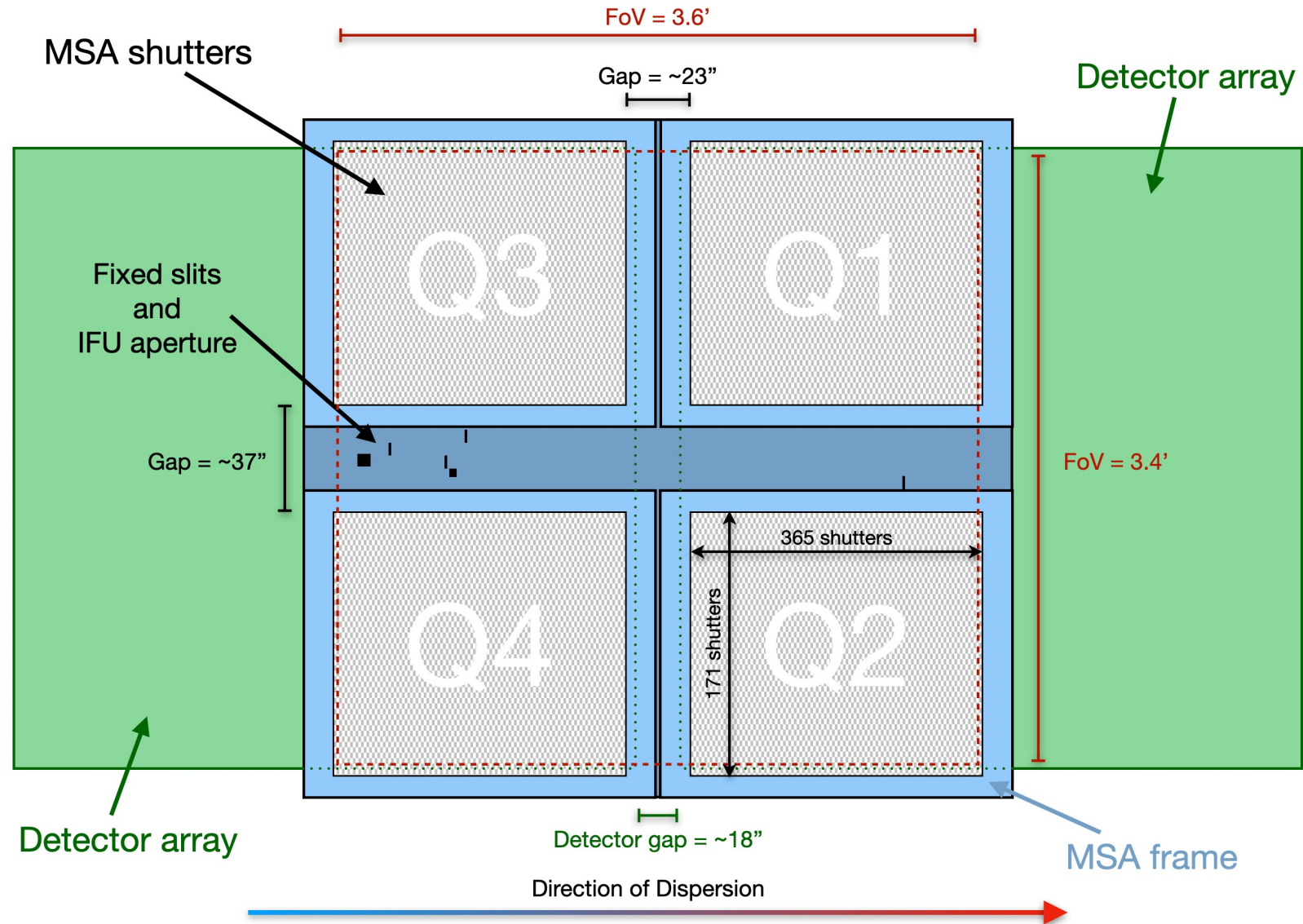
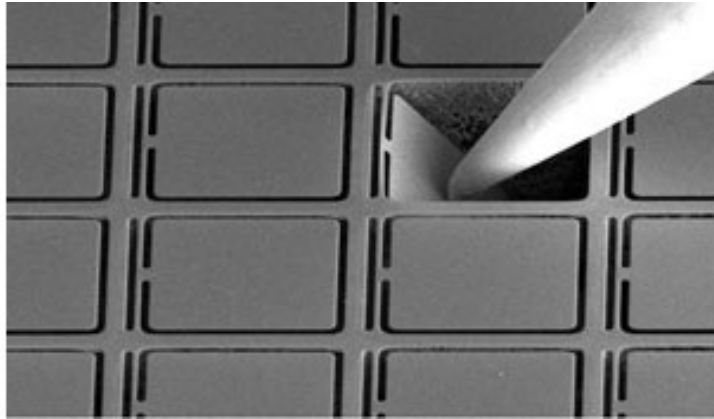
MPT (MSA Planning Tool)  
MSA (micro-shutter assembly)





# NIRSpec MOS Observation Planning in APT w/ MPT

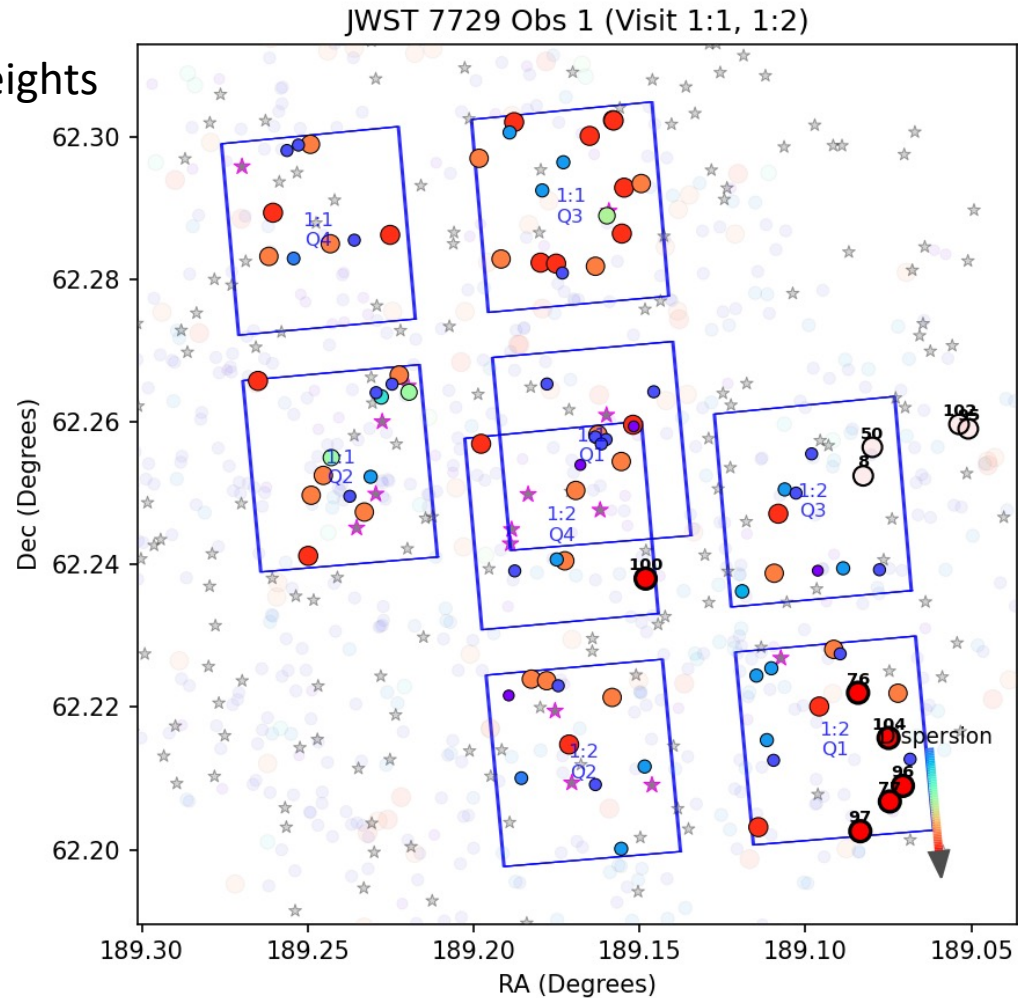
Diane Karakla  
Dan Coe, Kayli Glidic





# MPT tries to optimize pointings and slits on your catalog targets

You assign target priority weights  
MPT tries to maximize total



new review assistant

- Catalog: gdn-final-dr5-precise
- Highest Priority
- Observed Target
- Target
- Weight: 75,000
- Weight: 14,332
- Weight: 2,739
- Weight: 523
- Weight: 100
- ★ Observed Reference Object
- ★ Reference Object
- MSA Quadrants / Pointings

79  
139

SUMMARY

JWST 7729  
Unveiling Early Cosmic Enrichment: Direct Metallicities in z>6 Galaxies from Deep JWST Spectroscopy  
PI: Guido Roberts-Borsani

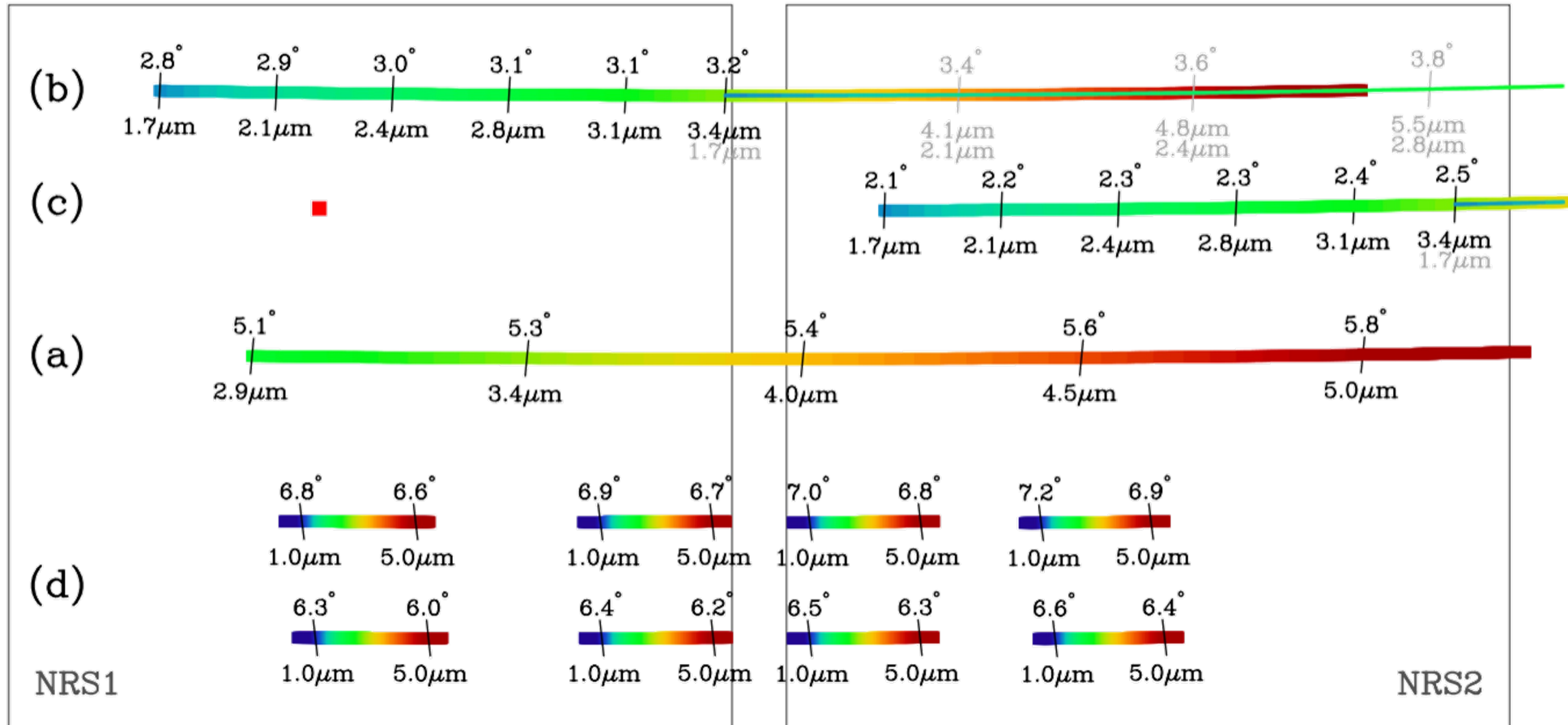
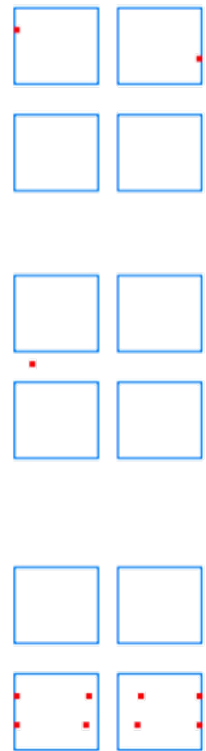
- ✓ 67.0 Hours Total Charged / 67.6 Hours Allocated
- 2 observations: 1, 2
- 1 observation REVIEWED: Obs 1
- ✓ Aperture PA Planned = Assigned
- ✓ MSATA: 6-8 stars in 2-3 quads
- ✓ Catalogs: 2 catalogs: gdn\_targets\_final, msa\_targets\_gds
- ⚠ IRS2 Readout NOT used in Obs 1
- ✓ Integration times all 429.5 s (< 1500 s)
- ✓ Nod Pattern: 3 Shutter Slitlet
- ⚠ 1 observation under construction: Obs 2



# NIRSpec MSA slits → detectors



P. Jakobsen et al.: The Near-Infrared Spectrograph (NIRSpec) on the James Webb Space Telescope





# NIRSpec MSA slits → detectors

MOS trace: JWST NIRSpec MSA → Detector Projections

### MSA Field of View

### NRS1

### NRS2

MSA Hover: Hovering over MSA...

MSA Selected: → Q3 Slit (355, 11)

NRS1 Trace:

|               |               |               |                                |
|---------------|---------------|---------------|--------------------------------|
| Q3 (355, 11): | X=[ 412,1811] | Y=[1981,1995] | $\lambda$ =[1.67,3.16] $\mu$ m |
| Q3 (183, 19): | X=[ 854,2048] | Y=[1944,1952] | $\lambda$ =[1.67,2.94] $\mu$ m |
| Q3 ( 11, 27): | X=[1286,2048] | Y=[1906,1909] | $\lambda$ =[1.66,2.47] $\mu$ m |
| Q1 (355, 35): | X=[1564,2048] | Y=[1866,1867] | $\lambda$ =[1.67,2.18] $\mu$ m |
| O1 (183, 43): | X=[2007,2048] | Y=[1824,1824] | $\lambda$ =[1.66,1.71] $\mu$ m |

NRS2 Trace:

|               |               |               |                                |
|---------------|---------------|---------------|--------------------------------|
| Q3 (183, 19): | X=[ 0, 62]    | Y=[1944,1944] | $\lambda$ =[3.10,3.16] $\mu$ m |
| Q3 ( 11, 27): | X=[ 0, 504]   | Y=[1906,1908] | $\lambda$ =[2.63,3.16] $\mu$ m |
| Q1 (355, 35): | X=[ 0, 782]   | Y=[1866,1870] | $\lambda$ =[2.34,3.17] $\mu$ m |
| Q1 (183, 43): | X=[ 0,1225]   | Y=[1824,1833] | $\lambda$ =[1.86,3.16] $\mu$ m |
| O1 ( 11, 51): | X=[ 257,1678] | Y=[1781,1796] | $\lambda$ =[1.66,3.16] $\mu$ m |

Click MSA to calculate or  Auto-calculate trace on hover  Plot multiple traces

Grid:  1  2x2  3x3

Disperser / Filter: **G235M / F170LP (1.66-3.07  $\mu$ m)** Clear Save Load

Fixed Slits:  S200A1  S200A2  S400A1  S1600A1  S200B1  ALL

PRISM / CLEAR

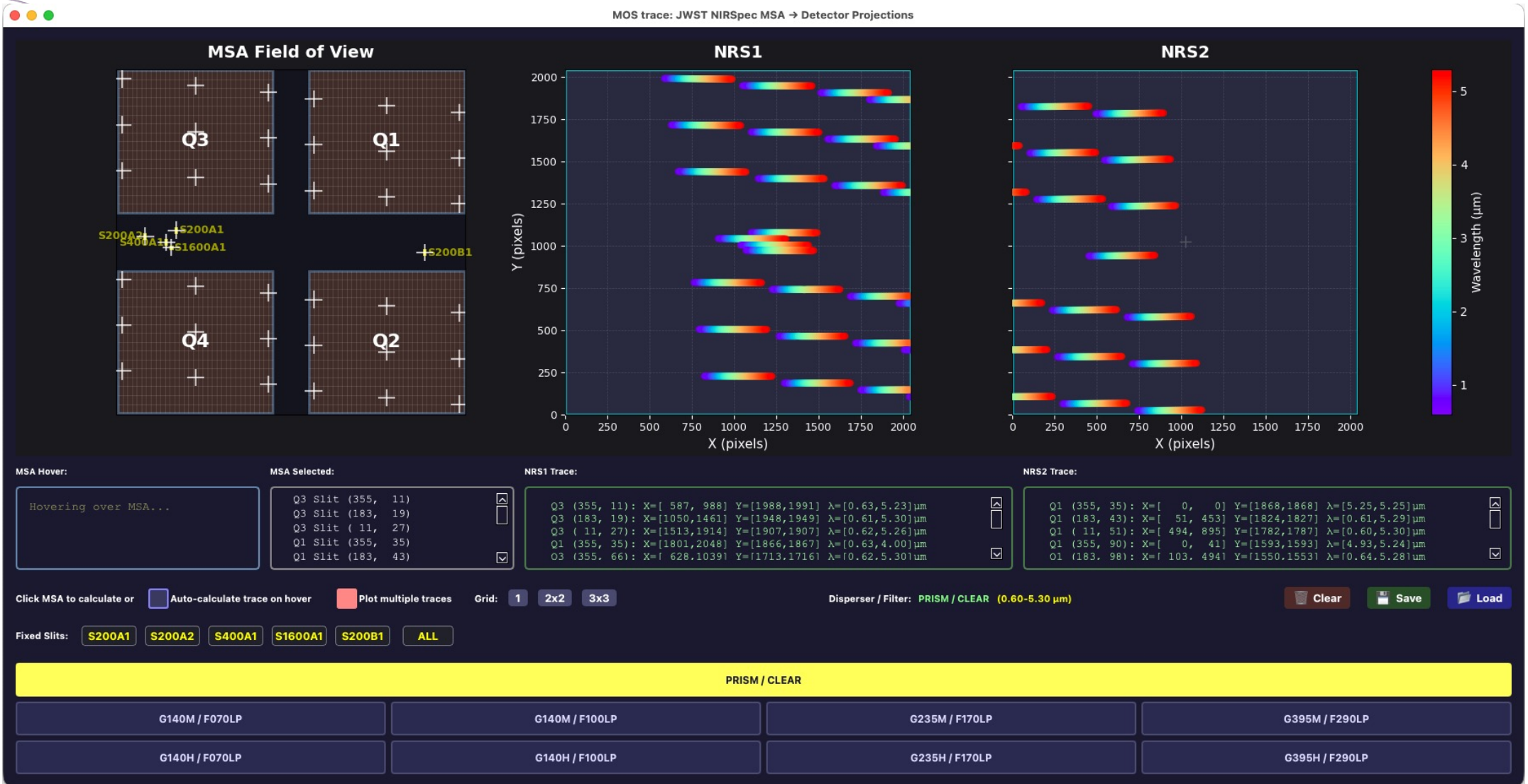
|                |                |                |                |
|----------------|----------------|----------------|----------------|
| G140M / F070LP | G140M / F100LP | G235M / F170LP | G395M / F290LP |
| G140H / F070LP | G140H / F100LP | G235H / F170LP | G395H / F290LP |



# NIRSpec MSA slits → detectors

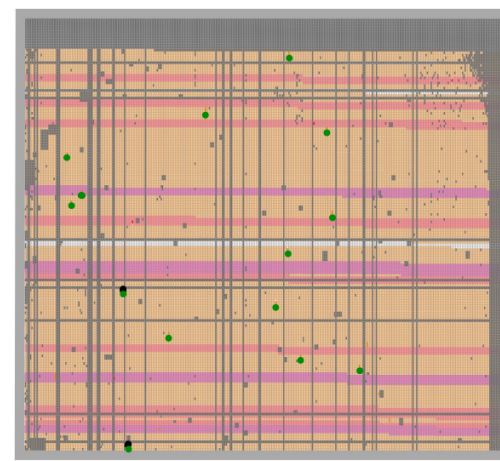
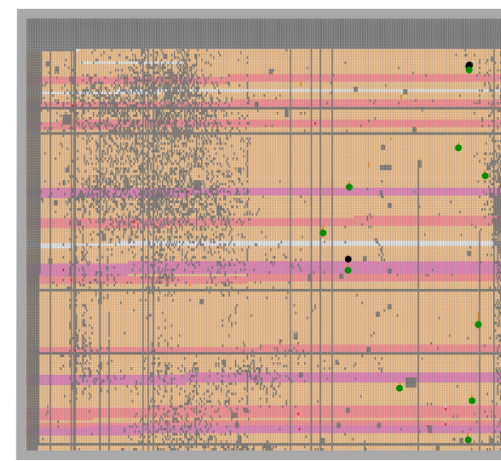
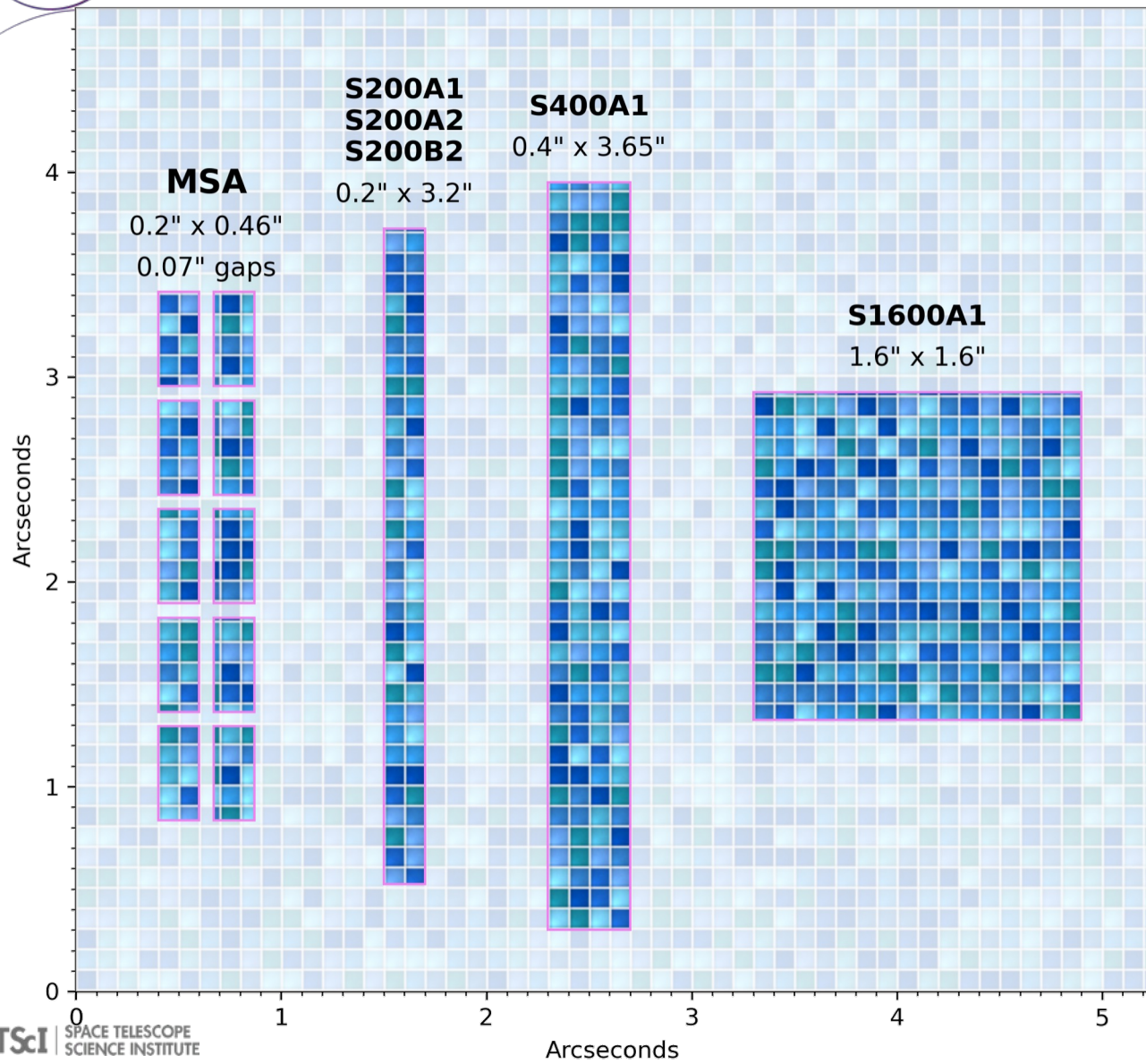


MOS trace: JWST NIRSpec MSA → Detector Projections



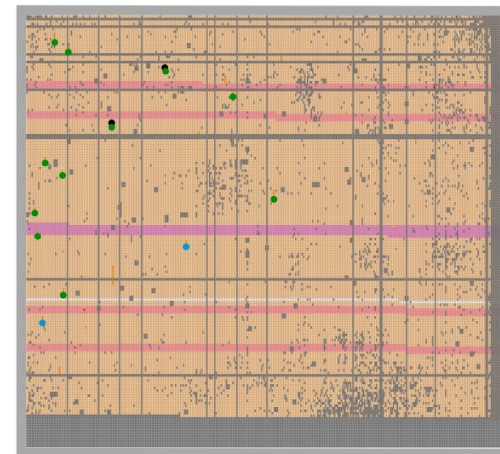
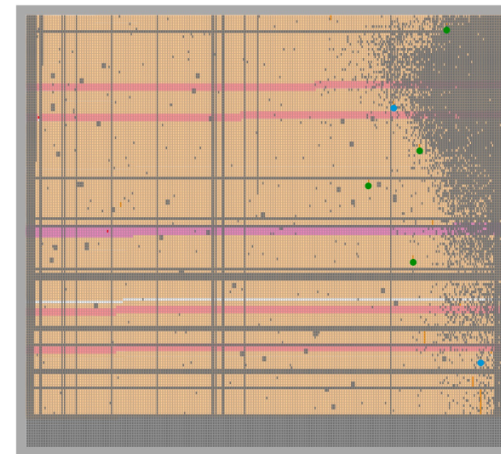


# NIRSpec MOS + Fixed Slits + detector pixels



□ IFU  
| 0.2" S200A1  
| 0.2" S200A2  
| 0.4" S400A1  
| 1.6" S1600A1

| 0.2" S200B1





# NIRSpec MOS always obtains Fixed Slit data too

can extract with our JDAT notebook

NRS1 | G235M | F170LP

NRS2 | G235M | F170LP

0.2" S200A1  
0.2" S200A2  
0.4" S400A1  
1.6" S1600A1

0.2" S200B1

PID 1166 Obs 7  
Confirmation images



# MPT

## MSA Planning Tool



Astronomer's Proposal Tools Version 2025.7.2 JWST PRD: PRDAPTSOC-072-002, Roman PRD: RPRDEVSOCS-021 - JWST Approved Proposal 5791 (JWST5791.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 | Tools | Stop

New Document | New | Search | What's New | Roadmap | Feedback

### The MSA Planning Tool for JWST NIRSpec MOS Proposals

Planner | Plans

**Candidate Lists**

MSA Catalogs: tr14\_jwst\_targets\_weighted\_cl1 (4850 sources)

Primary Candidate List: tr14\_jwst\_targets\_weighted\_cl1 (4850 sources)

Filler Candidate List: None Selected

**Plan Angle**

Aperture PA: 237.1746 Degrees

**Slit Setup**

Slitlet: 3 Shutter Slitlet | Constrained | Source Centering Constraint

**Pointing Setup**

Pointing Mode:  Grid Search  
 Fixed Pointings  
 MOS + Fixed Slit

Nod in slitlet: 3 exposures per configuration.

Fixed Dithers:  Short dithers recommended

| # | Dispersion (shutters) | Cross-Dispersion (shutters) |
|---|-----------------------|-----------------------------|
| 1 | 0                     | 0                           |
| 2 | -80                   | 0                           |

Pattern: [Empty]

Add | Insert Above | Remove

2 configurations per target set.

Partially Completed Primaries | Minimum Dither Points: 1

Partially Completed Fillers | Minimum Dither Points: [Empty]

[Advice for Grid Search Strategy](#)

Search Area Dimensions:

| Observa... | Number | Status | Execution ... | Execution ... | Duplication | Label | Instrument | Template | Coordinate... | Coordinate... | Targ |
|------------|--------|--------|---------------|---------------|-------------|-------|------------|----------|---------------|---------------|------|
|------------|--------|--------|---------------|---------------|-------------|-------|------------|----------|---------------|---------------|------|

Show: Observation

21 errors & warnings (Click for Details)



# Wavelength Ranges

Astronomer's Proposal Tools Version 2025.7.2 JWST PRD: PRDAPTSOC-072-002, Roman PRD: RPRDDEVSOC-021 - JWST Approved Proposal 5791 (JWST5791.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 | un All Tools | Stop

New Document | New | What's New | Roadmap | Feedback

### The MSA Planning Tool for JWST NIRSpec MOS Proposals

**Grating/Filter**

- G235H/F170LP
- G235M/F170LP
- G395H/F290LP
- G395M/F290LP
- PRISM/CLEAR

Multiple Sources Per Row    Min. Separation     Shutters

**Masking Setup**

|                    | Primary                  | Filler                   |   |
|--------------------|--------------------------|--------------------------|---|
| Mask               | None Selected            | None Selected            | <b>Import Mask</b>  |
| No Gaps            | <input type="checkbox"/> | <input type="checkbox"/> | <i>Spectrum must not extend into or through the detector gap</i>                      |
| No Red Cutoff      | <input type="checkbox"/> | <input type="checkbox"/> | <i>Red end of spectrum must not extend beyond the right edge of the NRS2 detector</i> |
| No Blue Cutoff     | <input type="checkbox"/> | <input type="checkbox"/> | <i>Blue end of spectrum must not extend beyond the left edge of the NRS1 detector</i> |
| Available Shutters | 182737                   | 182737                   |   |
|                    | <b>Export Mask</b>       | <b>Export Mask</b>       |   |

**Wavelength Range Setup**

|                    | Primary                  | Filler                   |   |
|--------------------|--------------------------|--------------------------|---|
| Wavelength Range 1 | <input type="checkbox"/> | <input type="checkbox"/> | <i>Defined in catalog as startwave1 to endwave1</i> |
| Wavelength Range 2 | <input type="checkbox"/> | <input type="checkbox"/> | <i>Defined in catalog as startwave2 to endwave2</i> |
| Wavelength Range 3 | <input type="checkbox"/> | <input type="checkbox"/> | <i>Defined in catalog as startwave3 to endwave3</i> |
| Wavelength Range 4 | <input type="checkbox"/> | <input type="checkbox"/> | <i>Defined in catalog as startwave4 to endwave4</i> |
| Wavelength Range 5 | <input type="checkbox"/> | <input type="checkbox"/> | <i>Defined in catalog as startwave5 to endwave5</i> |

**Parameters**

- Use Weights    Use sum of target weights for quality assessment.
- Enable Monte-Carlo    10 shuffles
- Allow the opening of shutters containing multiple sources
- Allow sources in areas affected by stuck open shutters

Number of configurations: 2    Enter N\*2 for N target sets.  
*If 'Number of configurations' is empty, tool will continue until all primary candidates are planned, or no more can be added to the plan.*

Observa... | Number | Status | Execution ... | Execution ... | Duplication | Label | Instrument | Template | Coordinate... | Coordinate... | Target

Show: Observation

21 errors & warnings (Click for Details)



Require range for any object



## Export to check

Export...

(Cmd-click to multiselect.)

- Diagnostic Summary [.diag]...
- PDF [.pdf]...
- Anonymized TAC PDF [.pdf]...
- TAC PDF [.pdf]...
- xml file [.xml]...
- Target Confirmation Charts
- Visit Coverage
- Visit Positions/Coverage to MAST
- MSA Target Info [.csv]...
- MSA Conflicts [.msaconflicts]...
- MSA Catalogs [.csv]...
- times file [.times]...
- pointing file [.pointing]...
- pointing.json file [.json]...
- timing.json file [.json]...
- records.json file [.records.json]...
- Smart Accounting visit sequences
- Proposal Information As HST .apt File
- sql file [.sql]...
- MOSS files to proposal directory
- Approved SQL file [.approved.sql]...
- SPAR SQL file [.spar.sql]...
- proposal as JAR format aptx file.
- MSA Configuration Change

Cancel    **OK**







## NIRSpec MOS APT – Common Suggestions / Requirements



- Catalog aligned to Gaia
- Enough reference stars / compact galaxies (FWHM < 0.2")
- Integration times < 1,500 s
- Dither if deep
- High priority targets:
  - Full depth
  - Wavelength coverage
  - Open more shutters? (e.g., 5 long)
  - Fixed Slit + MOS?



## NIRSpec MOS APT Submission Timeline

-  • Proposal
  - Acceptance? Congrats!
-  • Revisions? – # visits, pointings; constraints?
  - Scheduling + Angle Assignment
-  • -8 weeks: MOS at assigned angle
-  • -4 weeks: Finalize APT
  - -2 weeks (Wed.) Flight Ready
  - Plan window start



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# JWST NIRSpec MOS pipeline

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Dan Coe

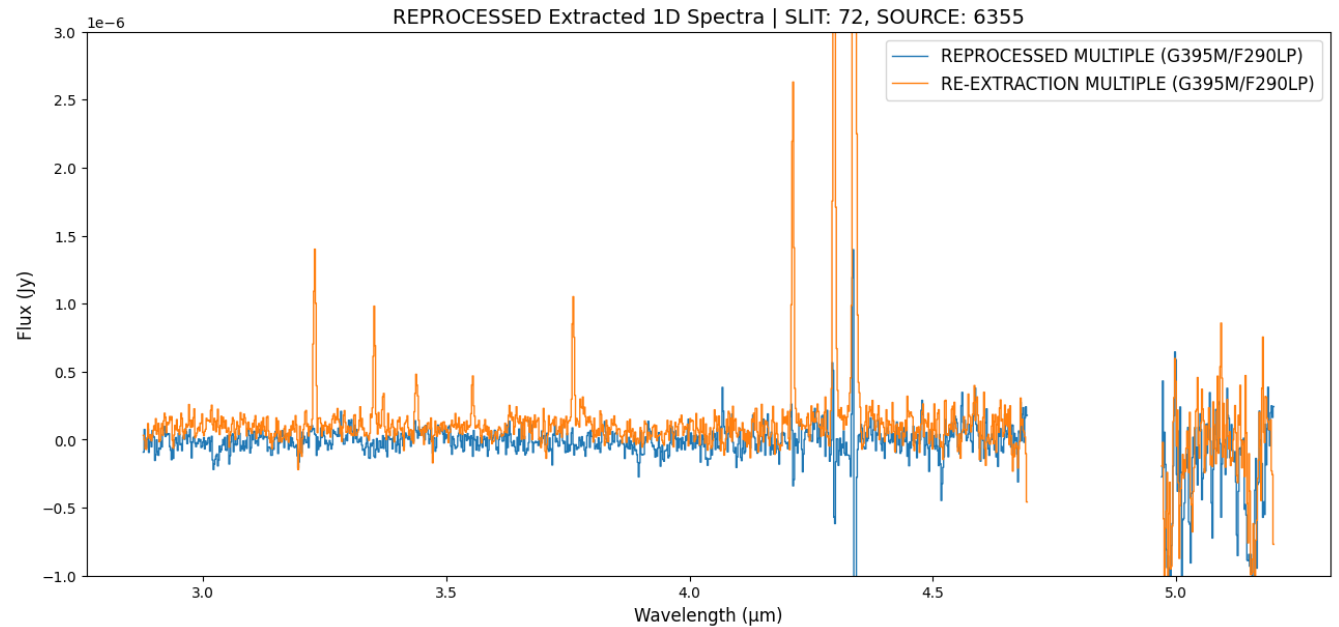
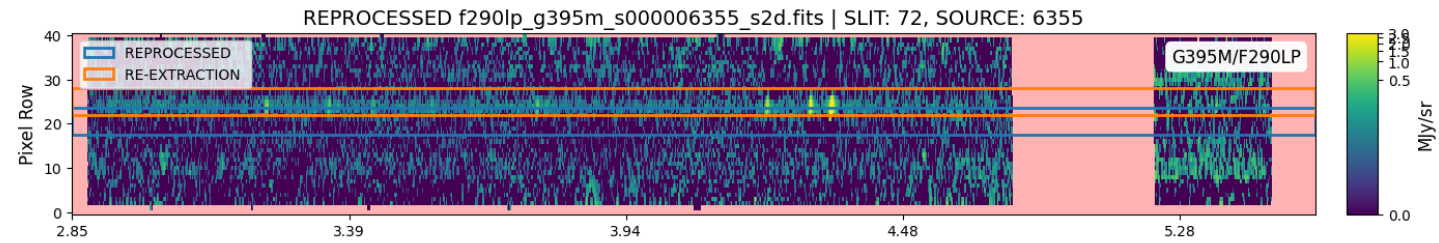
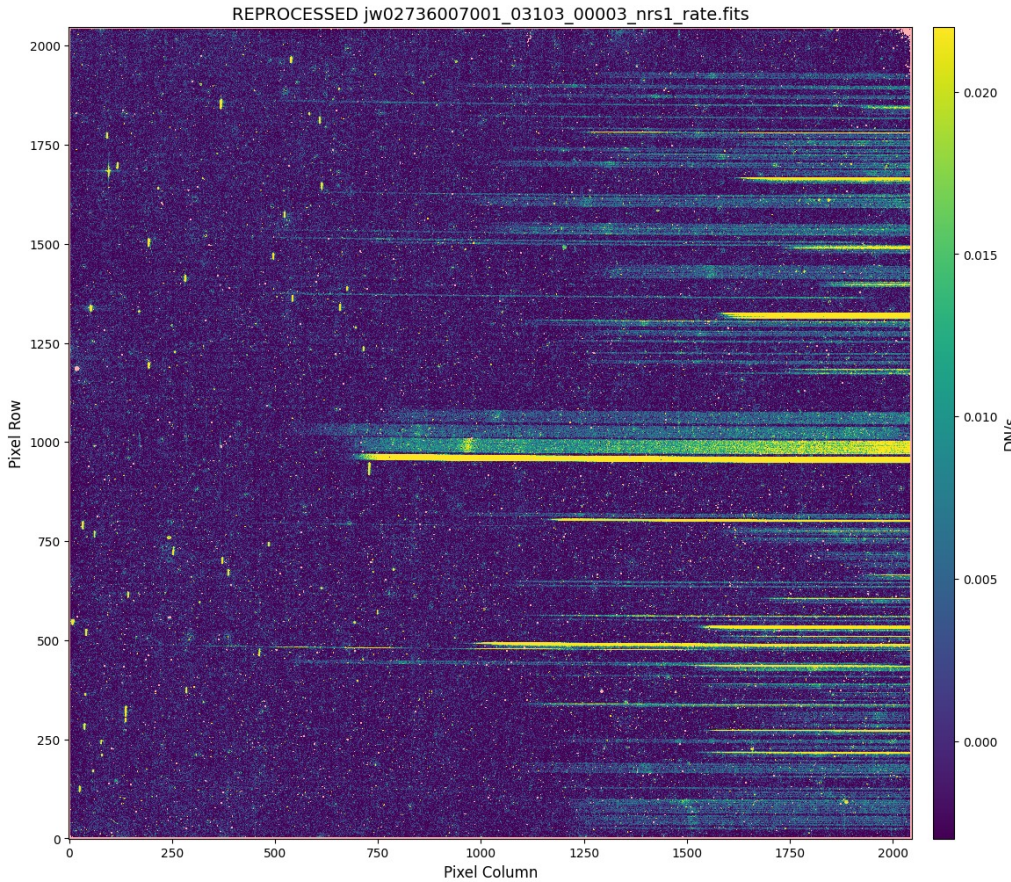
ESA/AURA Astronomer

NIRSpec Instrument Scientist



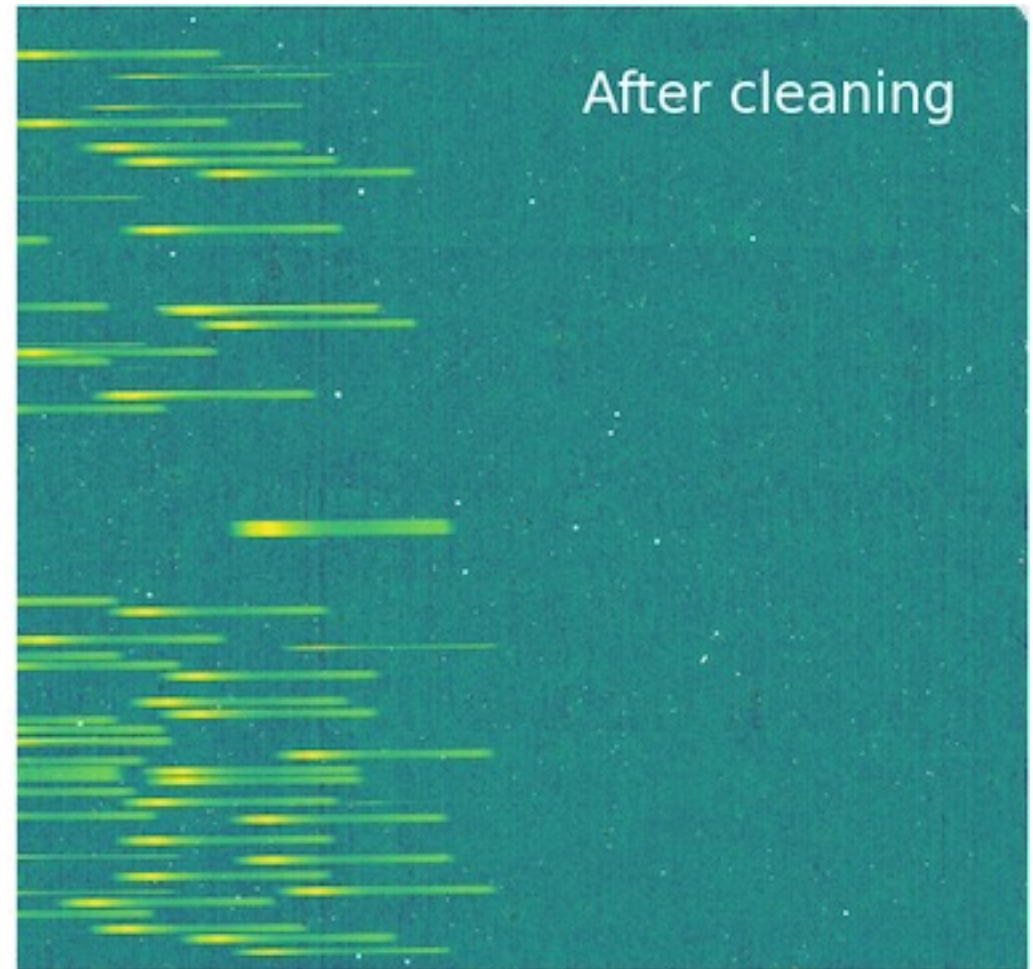
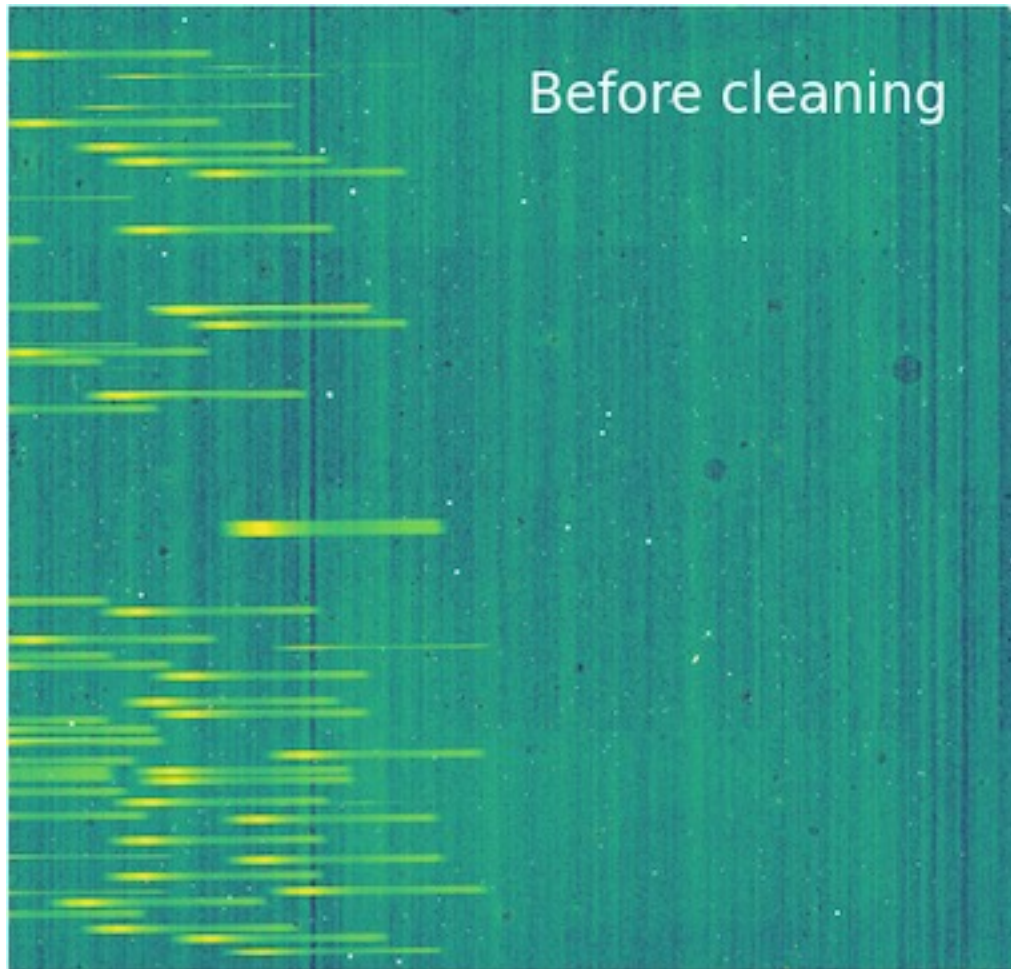
# NIRSpec MOS pipeline

<https://github.com/spacetelescope/jwst-pipeline-notebooks>  
[https://github.com/spacetelescope/jdat\\_notebooks](https://github.com/spacetelescope/jdat_notebooks)





# NIRSpec MOS - $1/f$ noise stripe removal - clean\_flicker\_noise

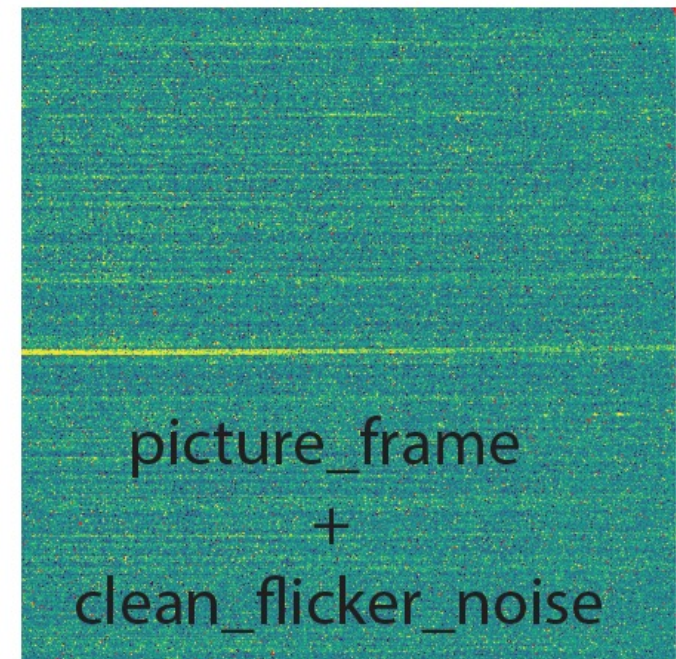
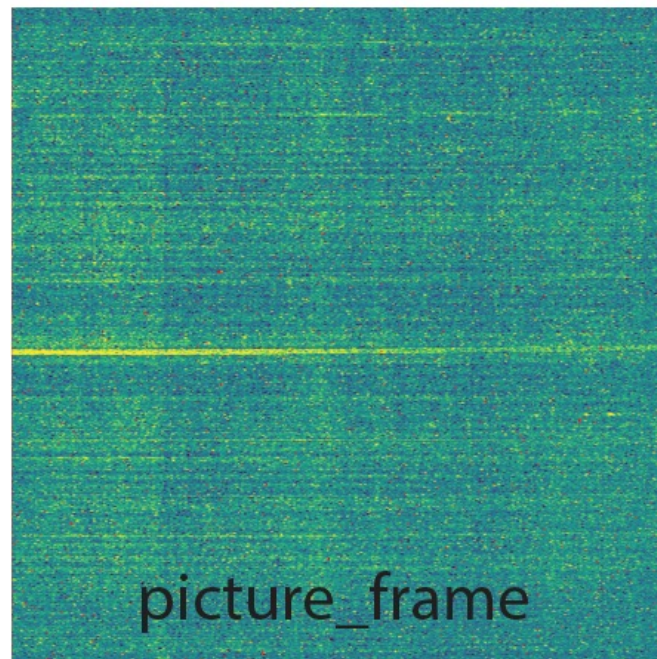
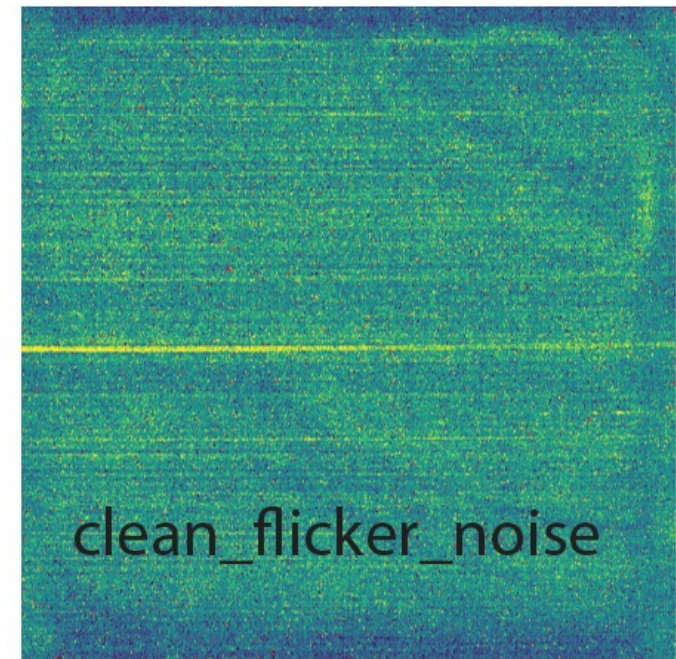
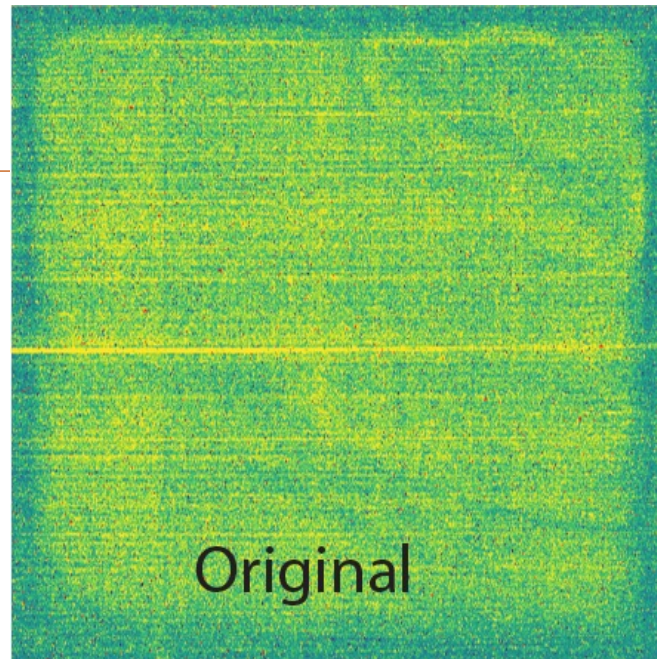




## Picture Frame Correction

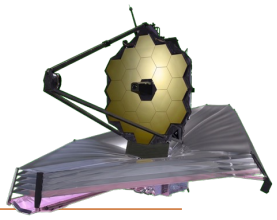
JDAT = JWST Data Analysis Tools

[https://github.com/spacetelescope/jdat\\_notebooks](https://github.com/spacetelescope/jdat_notebooks)





# JWST Pipeline v 2.0 coming April 17



to replace v 1.20.2

<https://jwst-pipeline.readthedocs.io>

- open source – pull requests welcome!

fundamental changes include:

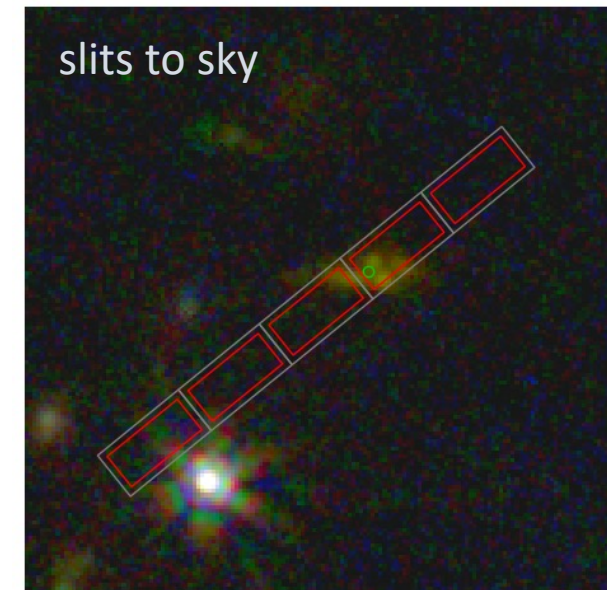
- memory usage reduced
- empty datamodels changed
- association yaml files deprecated



NIRSpec notebooks demo recent updates and provide tools:

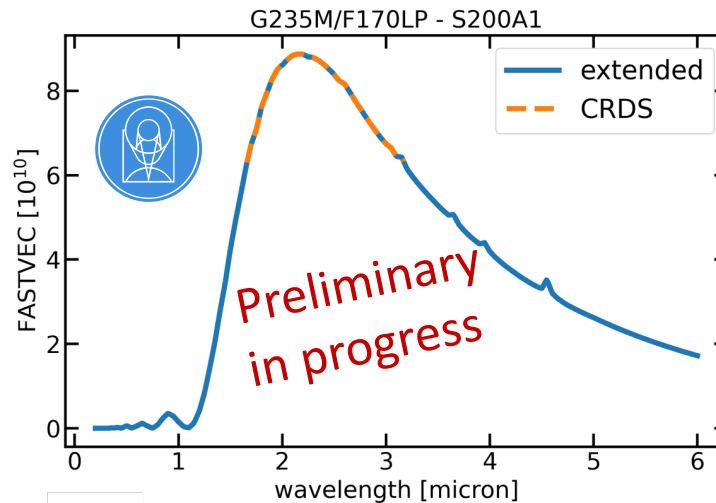
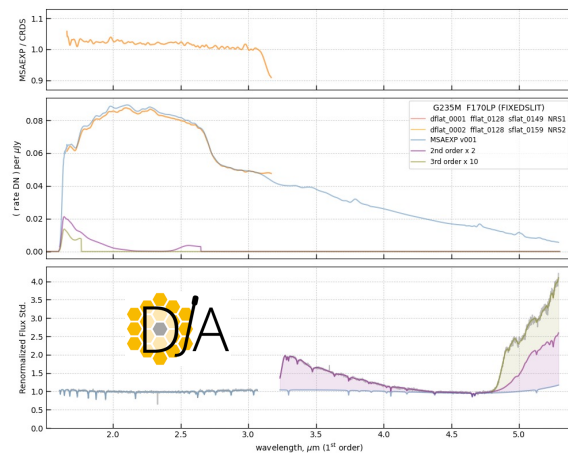
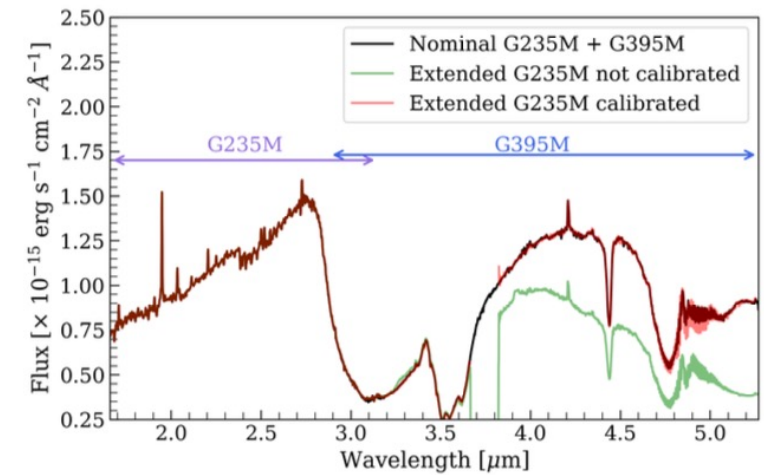
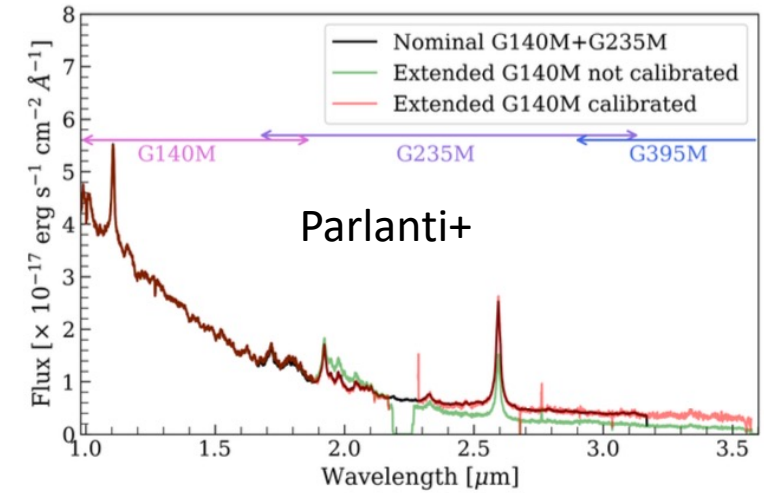
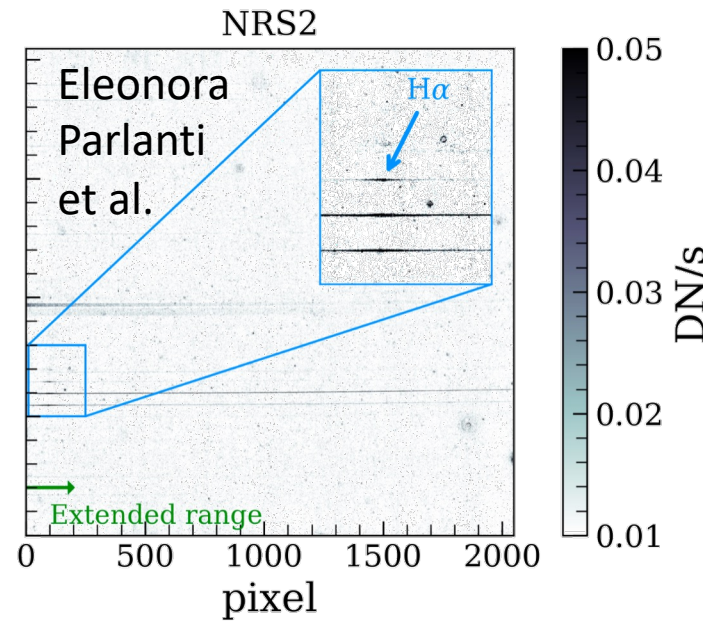
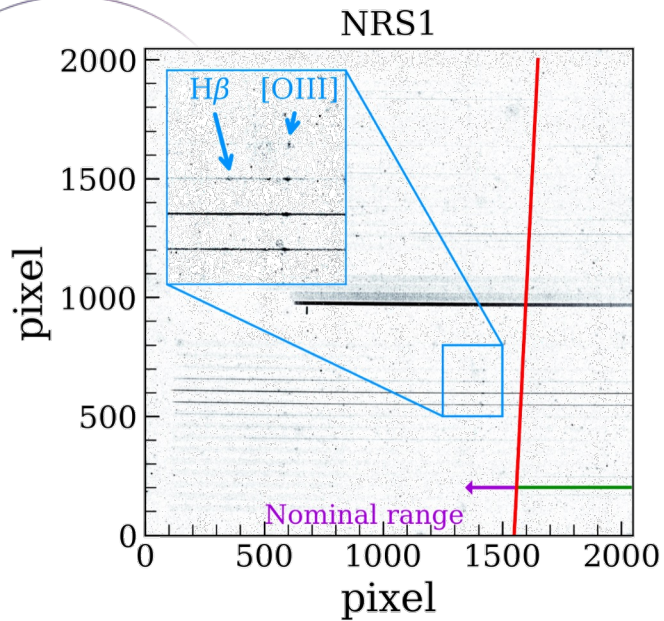
[https://github.com/spacetelescope/jdat\\_notebooks/tree/main/notebooks/NIRSpec](https://github.com/spacetelescope/jdat_notebooks/tree/main/notebooks/NIRSpec)

- 1/f noise removal `clean_flicker_noise`
- master background
- extract fixed slit from MOS data (coming soon)
- slits to sky mapping
- MSA metafile
- and more...





# NIRSpec Wavelength Extension (~doubled for G140M & G235M!)





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# JWST NIRSpec MOS calibration

---

Dan Coe

ESA/AURA Astronomer

NIRSpec Instrument Scientist



# NIRSpec Calibration

JWebbinar #48

next Wed Apr 22

Peter Zeidler

Recent updates:

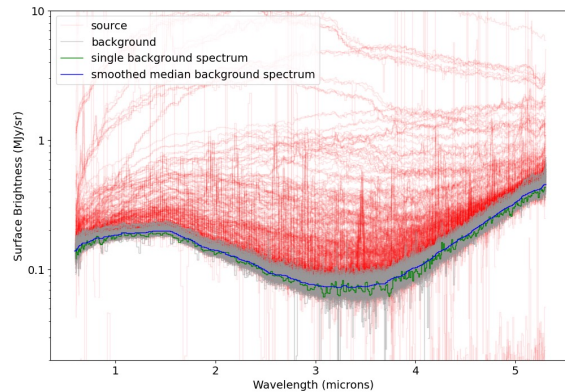
1. Flats (MOS, FS, IFU)
2. Pathloss (MOS, FS)
3. Background subtraction
4. IFU “wiggles”
5. IFU distortion model

In progress:

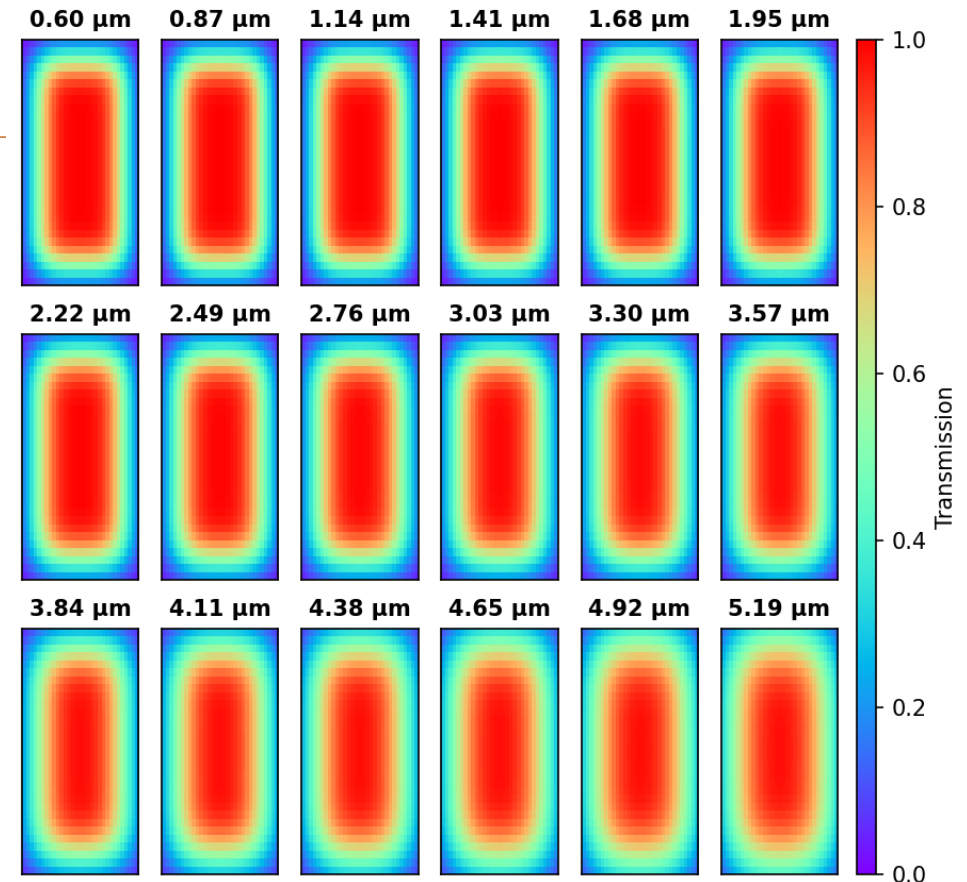
1. Wavelength extension
2. LSF = line spread function
3. IFU PSF centroid wander

Planned:

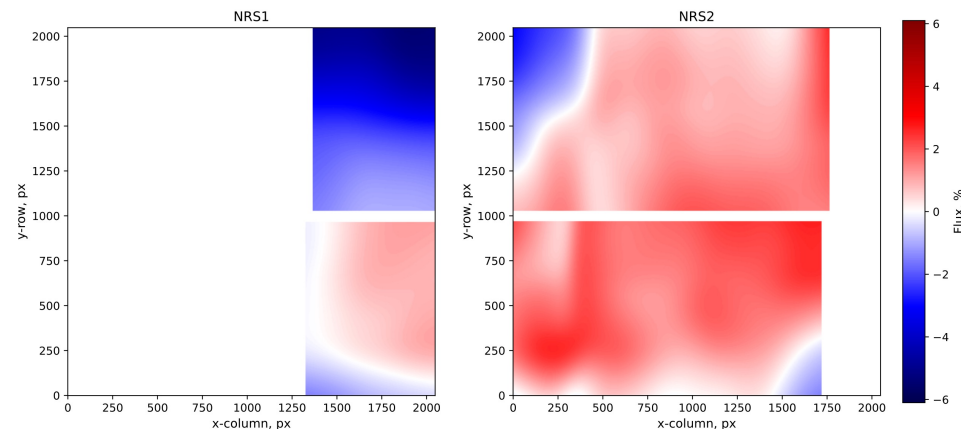
1. PSF-based extraction
2. IFU S-Flat
3. IFU wavelength gap – F-flat H-grating



## MOS Pathloss



NIRSpec MOS S-Flat G395M, Monochromatic image  $\lambda = 4.94672\mu\text{m}$



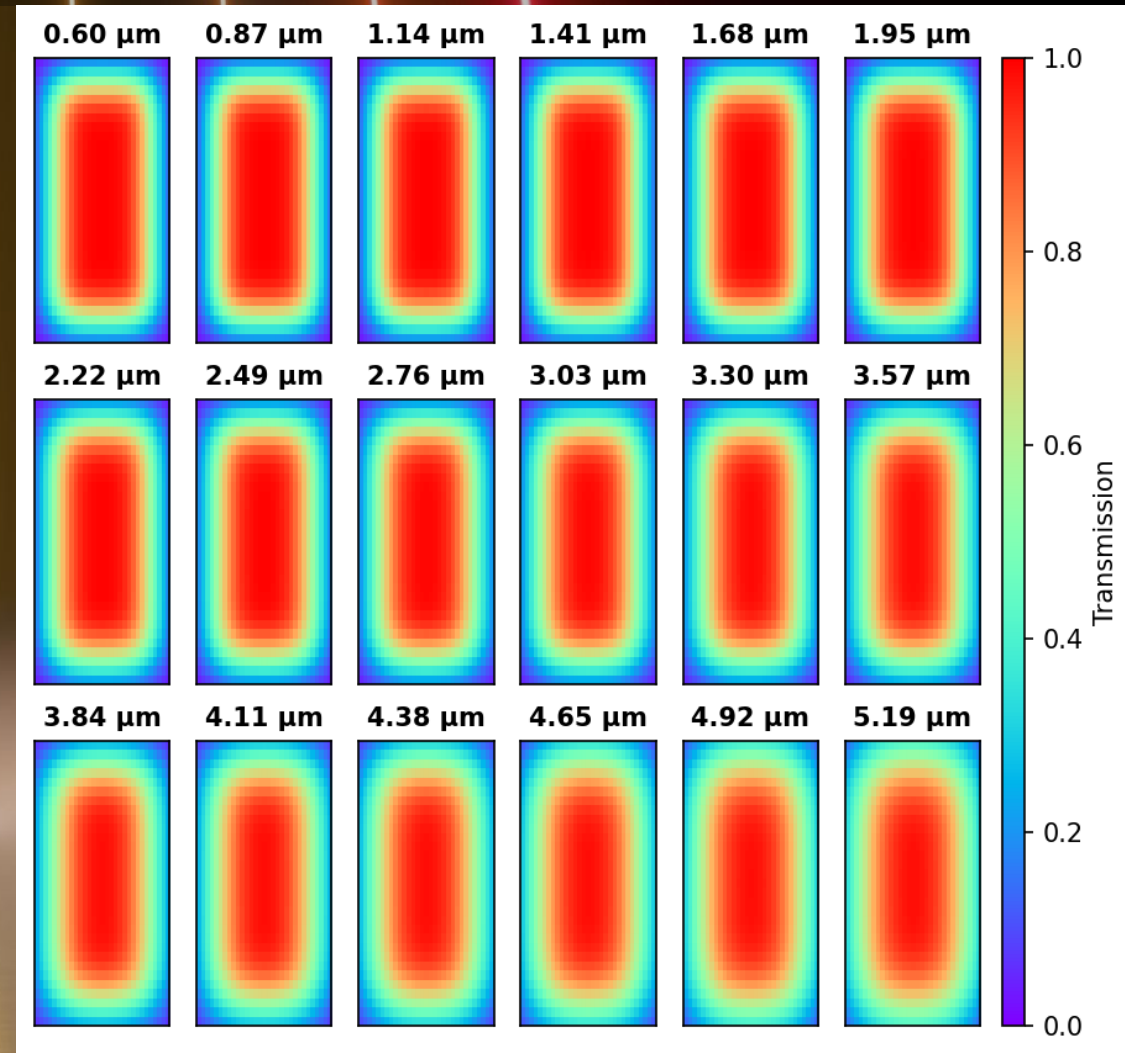
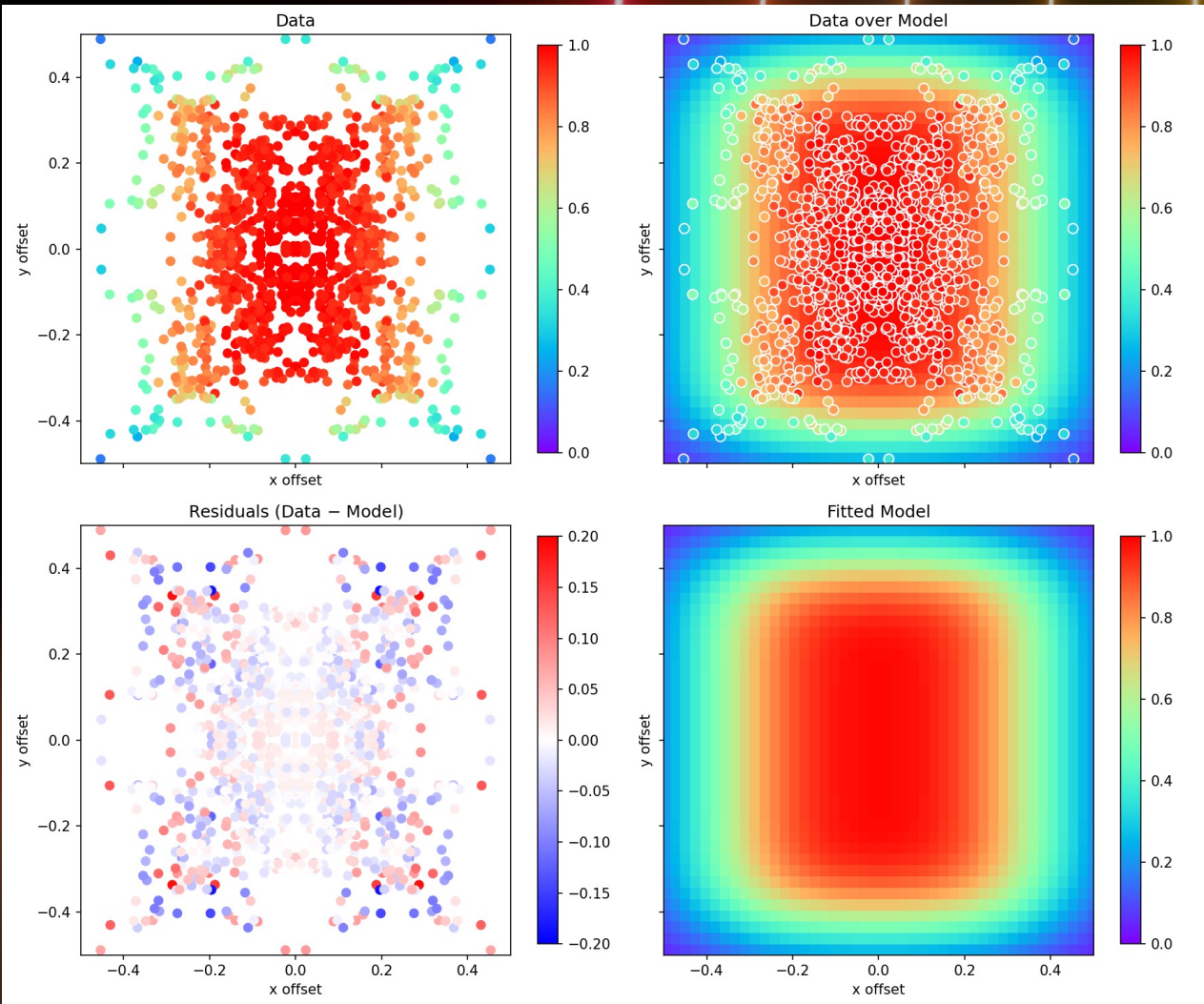
# NIRSpec Pathloss



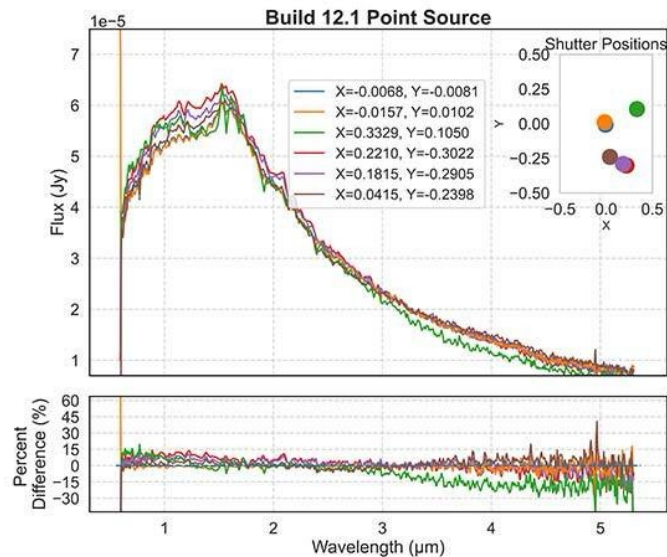
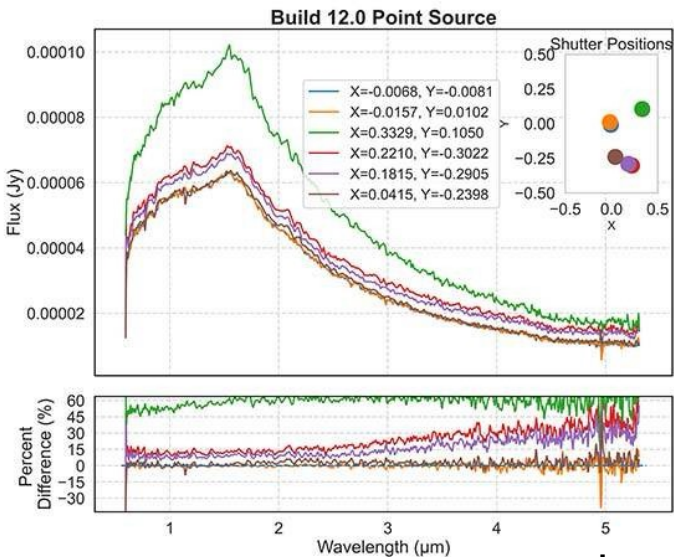
# NIRSpec Pathloss



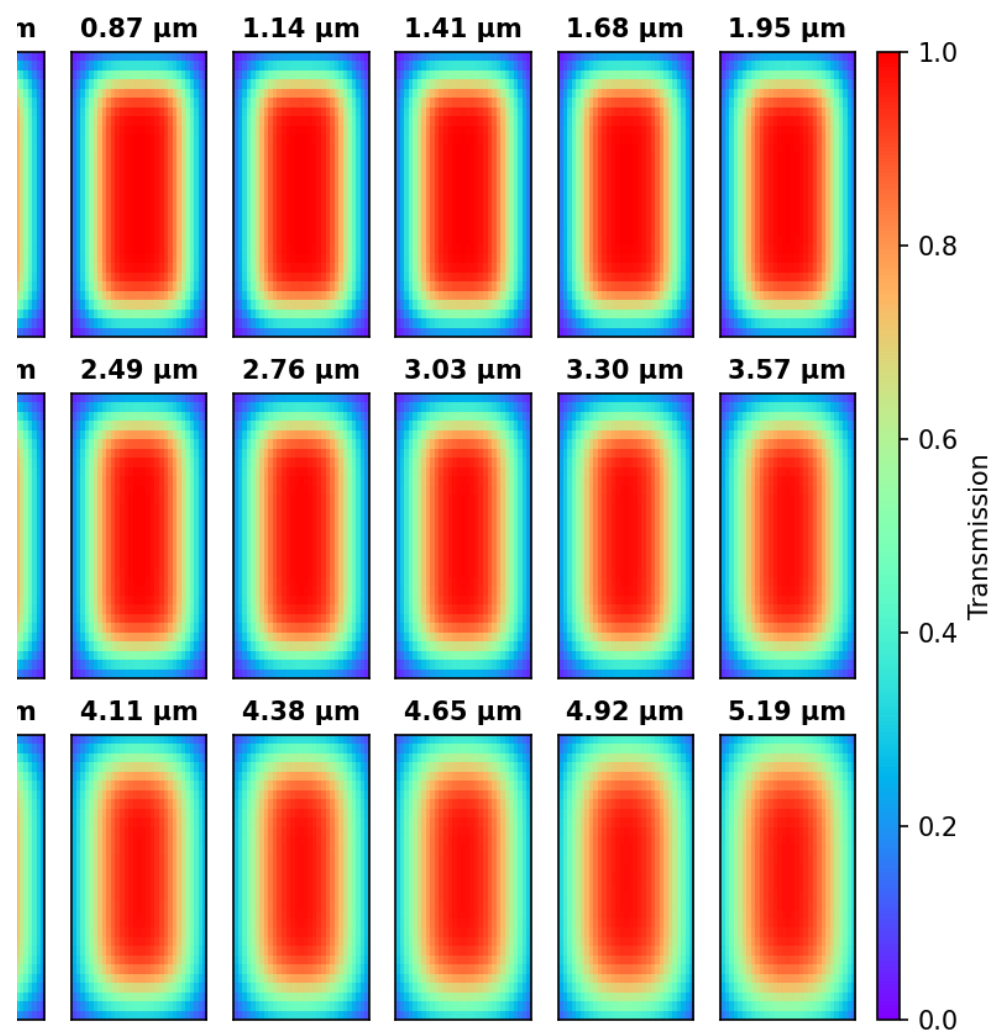
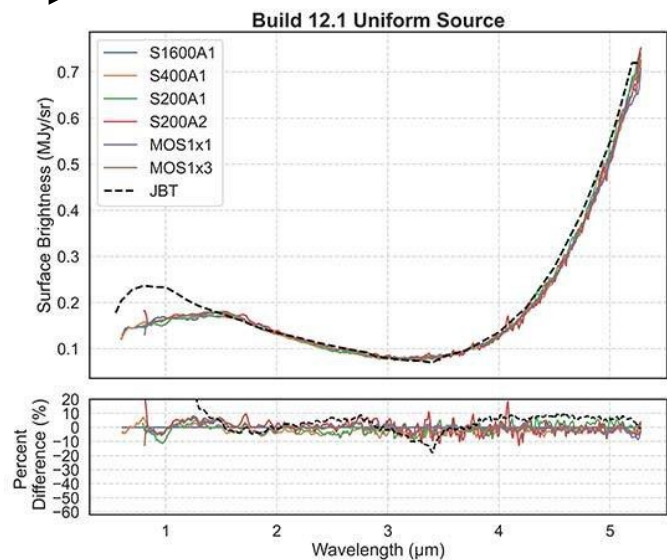
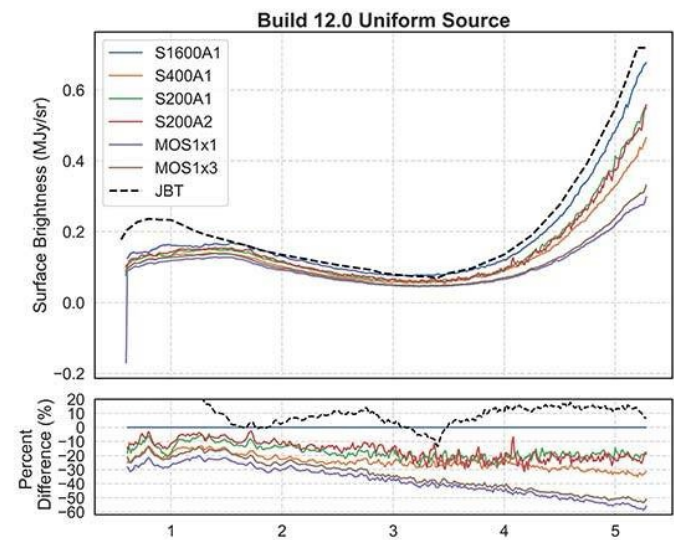
2.95  $\mu\text{m}$



# NIRSpec Pathloss

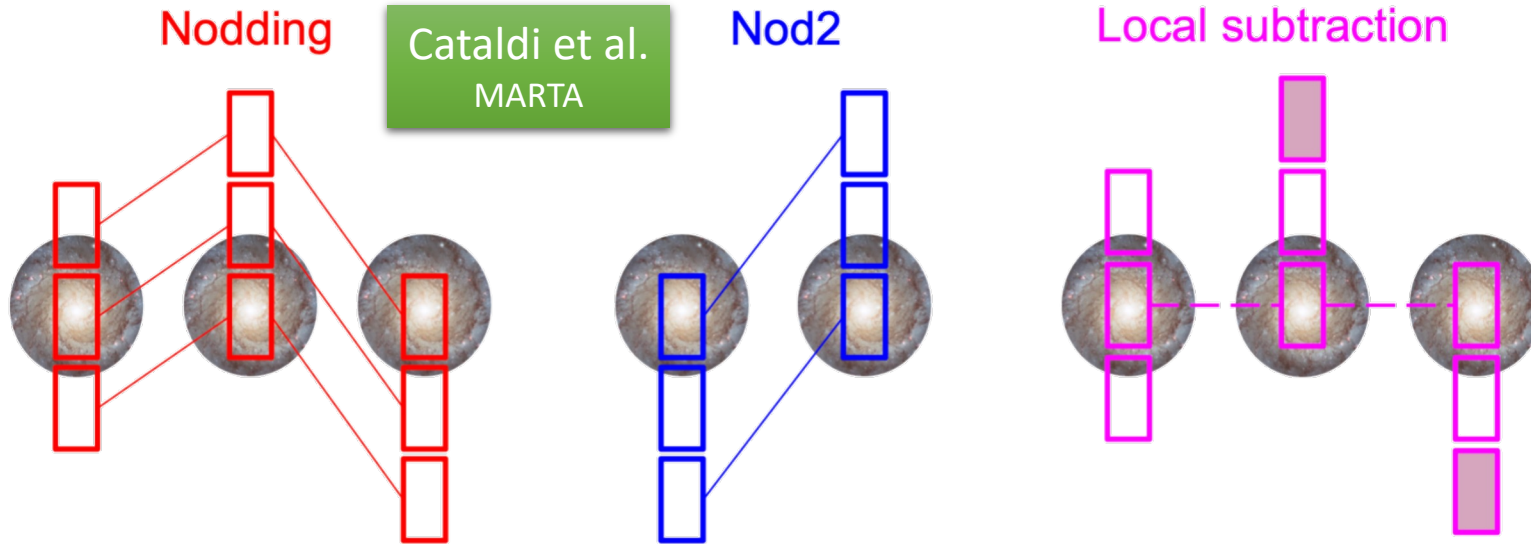


Improvement

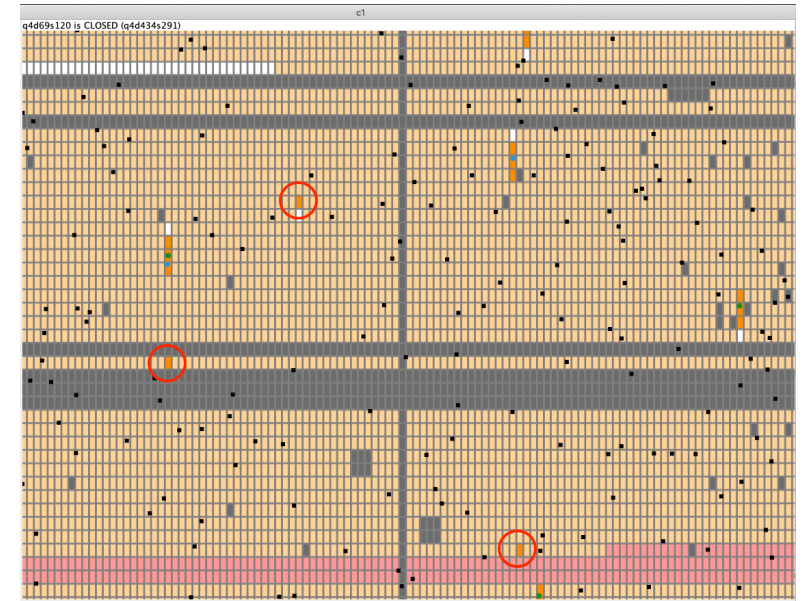




# Background measurement & subtraction

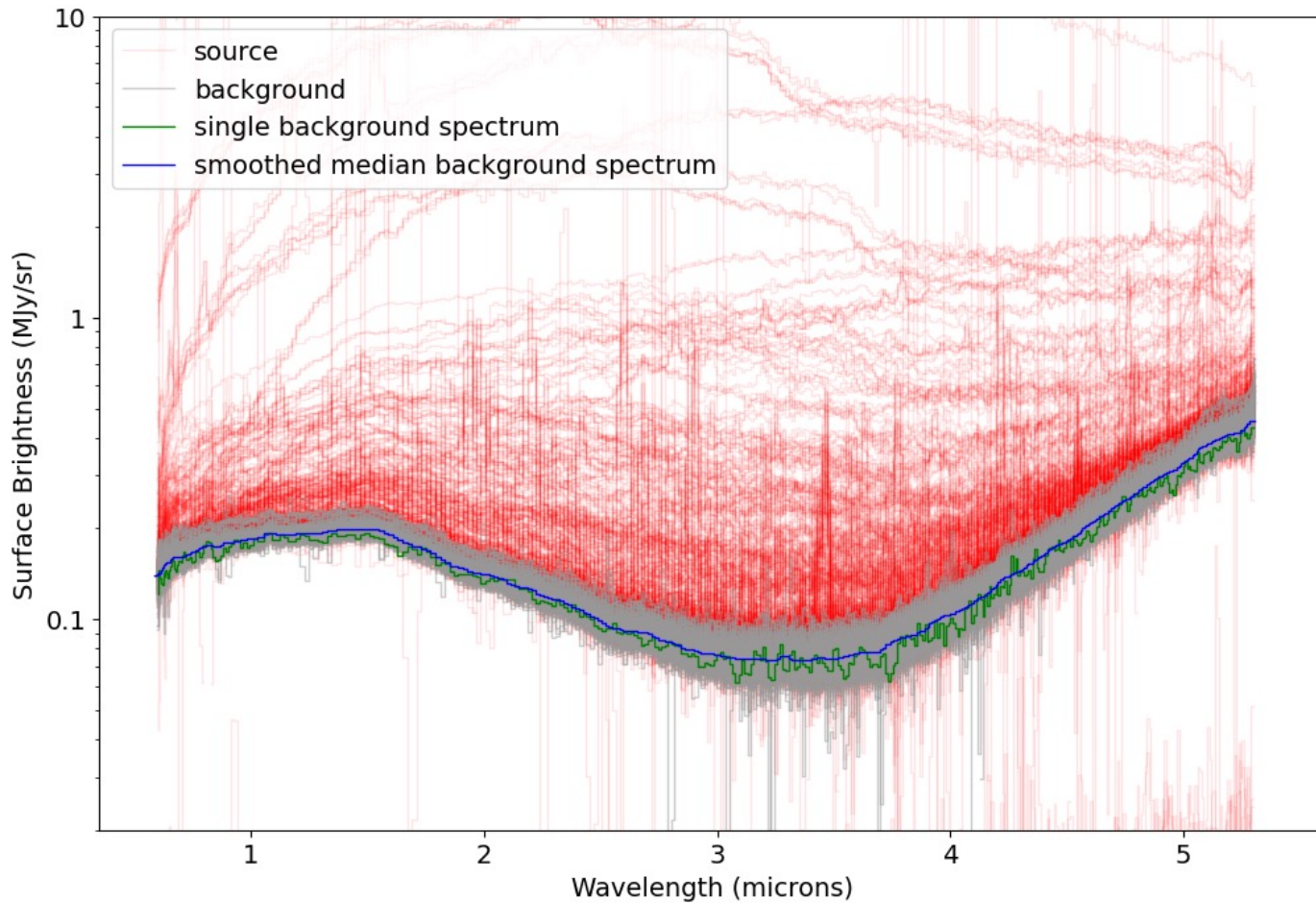


median from nearby empty slits





# Median background measurement improvement



median from nearby empty slits

q4d69s120 is CLOSED (q4d434s291)

Shutters

Collapsed Shutters

Export to CSV Send shutters to Aladin Import CSV Open all Close all

HUDF-UNORDERED  
 Z>4  
 Z>3

Left click to open/close shutters. Ctrl + Left click to open/close rows.

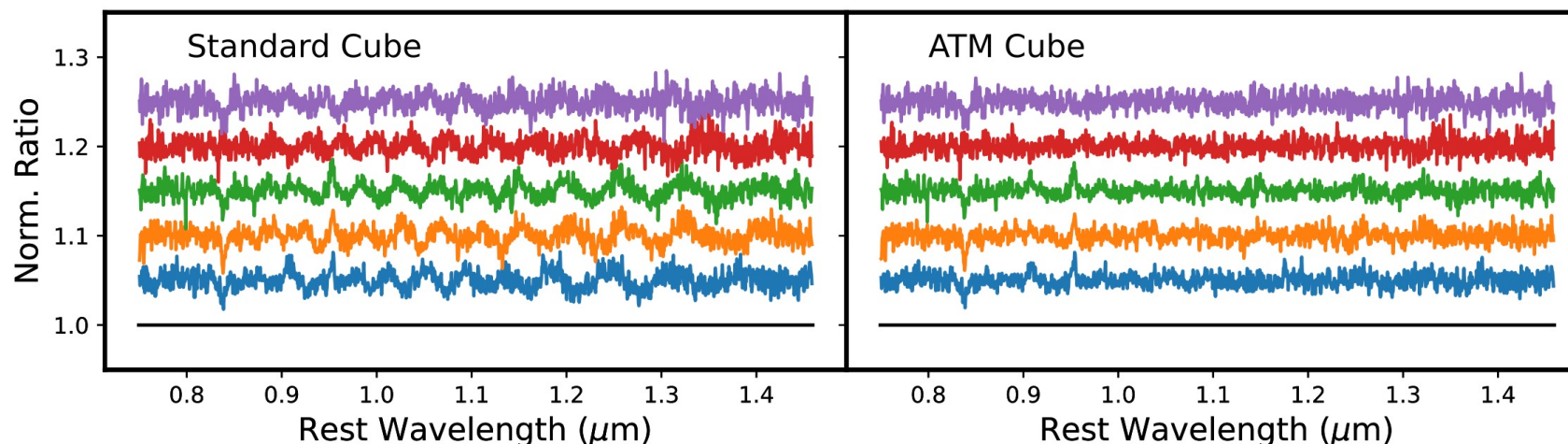
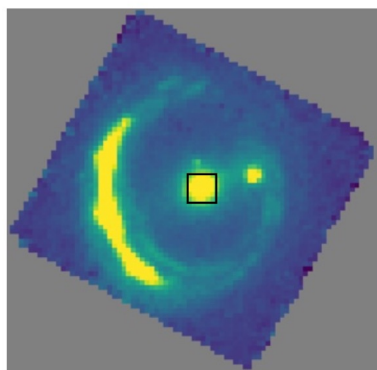
Configuration Name: c1  
Base Pointing RA: 03 32 39.9090 Dec: -27 47 14.15

Dispersion Offset (Shutters)  
Cross-Dispersion Offset (Shutters)

Master Background

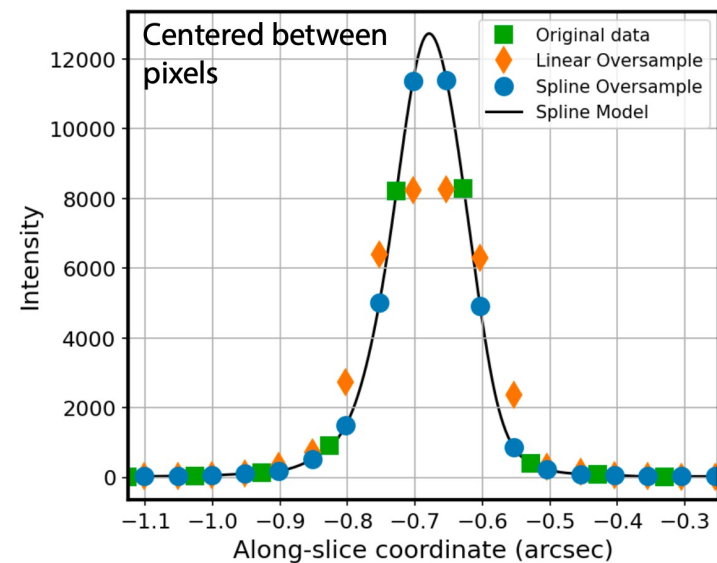
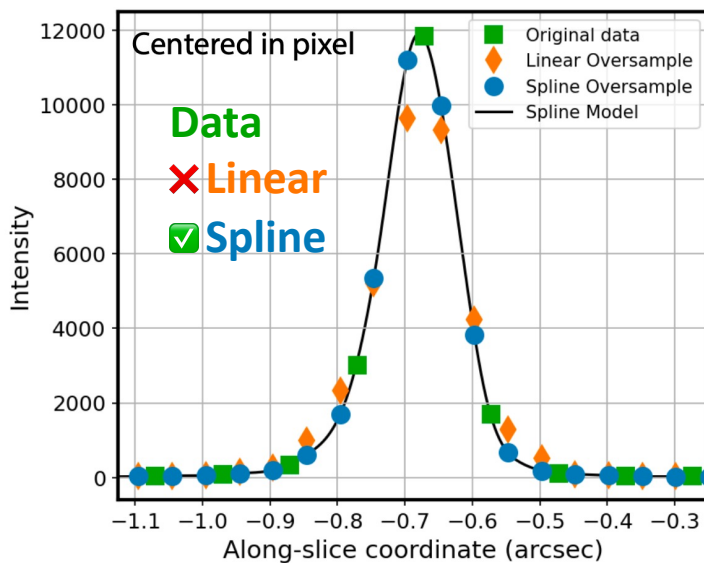


# IFU Wiggles Corrected in individual spaxels: NIRSpec MOS, MIRI MRS



IFU ADAPTIVE TRACE MODELING

7



IFU Adaptive Trace Model  
 David Law & Melanie Clarke  
 (2026) arXiv:2603.2691  
 Not on by default; reprocess  
 Requires continuum bright enough



# Summary of Current NIRCam Calibration Accuracies

JWebbinar #47

| Calibration                              | Accuracy   |
|--|--|
| <b>Bias, readnoise</b>                   | Steady   |
| <b>Flats</b>                             | ~1% Wisp noise reduced 40%   |
| <b>Backgrounds</b>                       | 5-10% agreement with models  |
| <b>Absflux Imaging &amp; weak lenses</b> | <2% for most filters/detectors (down from 3-4%), many are <1%                |
| <b>Absflux coron</b>                     | <1% (down from 1.5%), but LWB, SWB, and non-prime channels need more targets |
| <b>Absflux grism</b>                     | ~3% (for combined grisms/modules)  |
| <b>Flux stability</b>                    | <0.5% reduction/year   |

| Calibration                            | Accuracy  |
|--|---|
| <b>Subarray flux transfer</b>          | <1%, most cases. Smallest subarrays ~2%. Worst is ~3%.              |
| <b>Stellar L-flats</b>                 | 1-2% variation across SCAs  |
| <b>Grism trace</b>                     | ~0.1 pix (down from 0.2 pix)  |
| <b>Grism spec cal</b>                  | ~1.7 Å (down from 2 Å)  |
| <b>Coron TA</b>                        | <15 mas   |
| <b>Distortions/alignment (imaging)</b> | Relative position btwn SCAs <0.01"<br>Orientations < 0.001°         |
| <b>Distortions/alignment (coron)</b>   | SW: 2-3 mas (down from 5-10 mas)<br>LW: 3-6 mas (down from >10 mas) |



# JWST Documentation, Help, Notebooks



JDocx – JWST Documentation <https://jwst-docs.stsci.edu>

JWST Help Desk – <https://jwsthelp.stsci.edu>

JWST Office Hours – <https://outerspace.stsci.edu/spaces/JEA/pages/232358818/Webb+Office+Hours>

JWebbinars – <https://www.stsci.edu/jwst/science-execution/jwebbinars>

JWST pipeline (open source; pull requests welcome!)

- <https://jwst-pipeline.readthedocs.io>

JWST pipeline notebooks

- <https://github.com/spacetelescope/jwst-pipeline-notebooks> + outputs = <https://spacetelescope.github.io/jwst-pipeline-notebooks>

JDAT = JWST Data Analysis Tools

- [https://github.com/spacetelescope/jdat\\_notebooks](https://github.com/spacetelescope/jdat_notebooks) + outputs = [https://spacetelescope.github.io/jdat\\_notebooks](https://spacetelescope.github.io/jdat_notebooks)

Our high-z community  
can organize to  
share best practices  
(as they do for exoplanets?)