



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

JWST Pipeline Development

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Overview: JWST Pipeline (JP) Coordination Team

The JWST pipeline will never automate everything for everybody, but it should be capable of doing most things for most people.

In January 2024, STScI adopted a new framework for management and oversight of the JWST pipeline.

- JWST Pipeline (JP) Coordination Team has broad responsibility for all issues relating to the quality of the data products and documentation thereof being provided to the community.
- Set priorities, cross-division communication within STScI. Investigate, delegate, and track issues as necessary.
- Led by D. Law and C. Hayes, with representatives from each instrument team.
- Common point of contact for questions and data-related issues.



Overview of JWST Pipeline Builds

A 'build' is a released and tagged set of software including the core 'jwst' package and related dependencies.

See [JDox](#) for the latest table

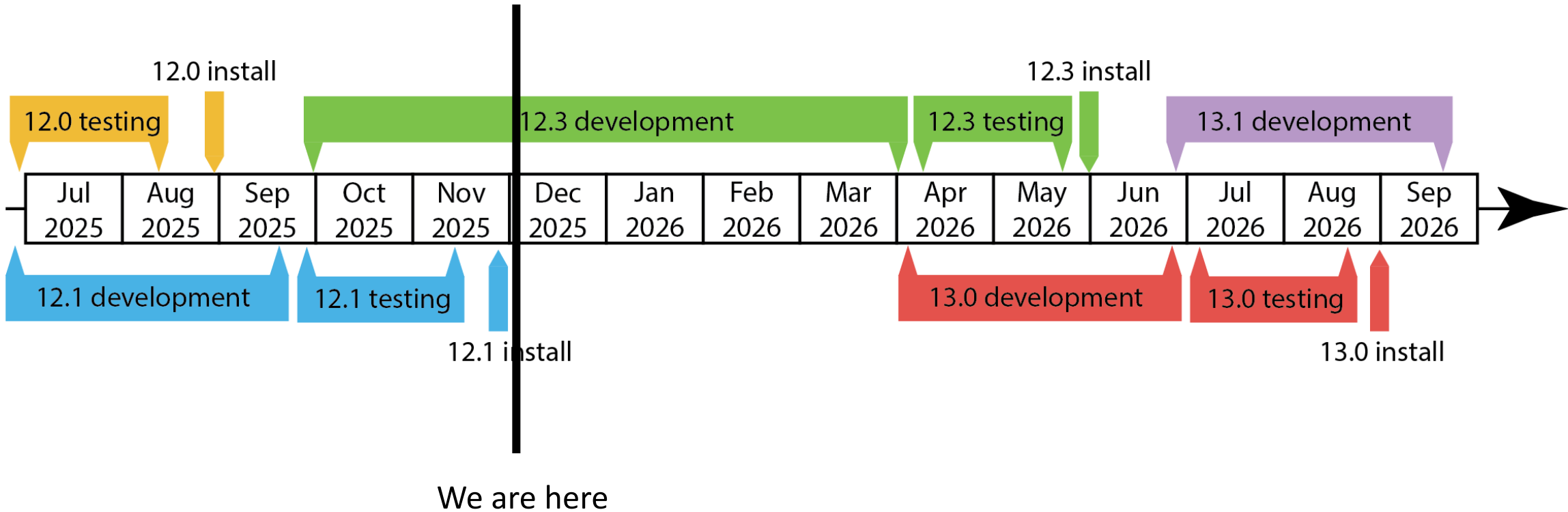
Operations Pipeline Build	Science Calibration Pipeline Version (jwst)	Build Status	SDP_VER	Candidate Released	Operations Installation	CRDS context
12.3	TBD	Development	TBD	Est. April 2026	Est. May 2026	TBD
12.1	1.20.1	Candidate	TBD	2025-10-20	Est. November 20 2025	1464
12.0	1.19.1	Operations	2025.3.1	2025-07-21	2025-08-26	1413
11.3	1.18.0 / 1.18.1	Archived	2025.2.0	2025-03-19	2025-05-20	1364

Build lifecycle:

- **Development**
 - Changing daily, not recommended for non-developers. 'jwst' main branch.
- **Candidate**
 - Development finished, working on testing and documentation. Available for interested users.
- **Operational**
 - Default recommendation for users. Used to produce MAST data products.
- **Archived**
 - Old versions that are no longer current or recommended

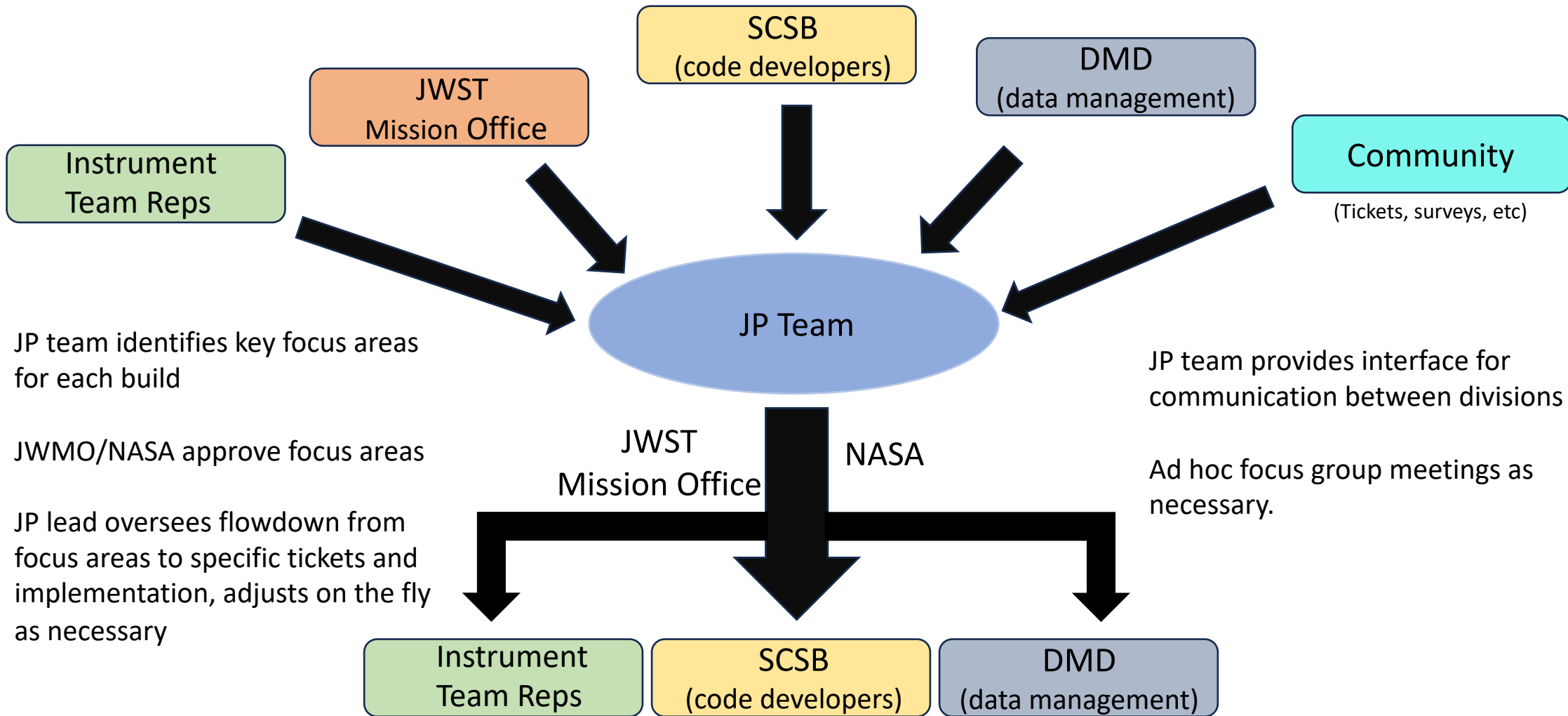


Where are we now?





JP Coordination Team Workflow





State of the pipeline: What are the most common user issues?

User feedback via 1-month/9-month surveys, helpdesk tickets, science collaborators. (These usually lag pipeline development by 6-12 months.)

- Improvements needed for TSO, WFSS, and MOS processing
- Removal of $1/f$ noise is now available in the pipeline, but requires reprocessing
- IFU undersampling artifacts make analysis challenging
- WCS alignment (particularly across large fields) can have problems
- Improvements to bad pixel and outlier rejection (some reports of recent improvements)
- Improvements to MIRI fringe correction

Examples of positive feedback:

- Appreciation of runtime improvements (particularly in stage 1 processing)
- Pipeline notebooks are helpful for users who want to reprocess their data



What's new in builds 12.0 and 12.1?

Since March 2025 JSTUC meeting, we have completed builds 12.0 and 12.1, starting build 12.3.

Highlights:

- Major reorganization/improvement of spectral data products from WFSS.
- Major reorganization/improvement of data products from TSO.
- 1/f improvements via SIRS and automatic 1/f optimization
- Updated NIRSpec IFU WCS infrastructure (ease of use plus speed gains).
- Changes to MIRI time-dependent throughput correction models
- Background subtraction for NIRISS SOSS using scaled models.
- Change to pipeline usage commands (must choose between methods)



Highlight: Changes to WFSS



Ned Molter

Data format changes:

- Previously each extracted source produced a 2D calibrated, 1D spectral, and 1D combined file. 100s-1000s of files from spec2/spec3 pipeline, names changed each build when small changes in source catalog. Major headache for both users and MAST.
- Now removed unnecessary duplicate files, combined all source spectra into a table within a single 1d spectral file. One file, with a fixed name, regardless of number and ID of sources.

Multiple bug fixes and runtime improvements to WFSS contamination correction step (~100x improvement); aim to enable in build 12.3



Highlight: Changes to TSO data products

Data format changes:

- Previously spectra from each integration were written to a unique FITS extension. Long TSO observations with 10,000+ integrations required >24 hours for pipeline to write this FITS file to disk.
- Now spectra from all integrations are in a table in a single FITS extension. Write time decreases from 24+ hours to seconds.
- Break data into segments of roughly equal length (e.g., 52/52/51 integrations, not 50/50/50/5 integrations)



Highlight: Changes to TSO data products

Allow production of final data TSO photometry products in units of e-/s

Add BJD_TDB time information and fix incorrect timestamps in TSO3 white light data products.

Add auto-centroiding for TSO imaging photometry

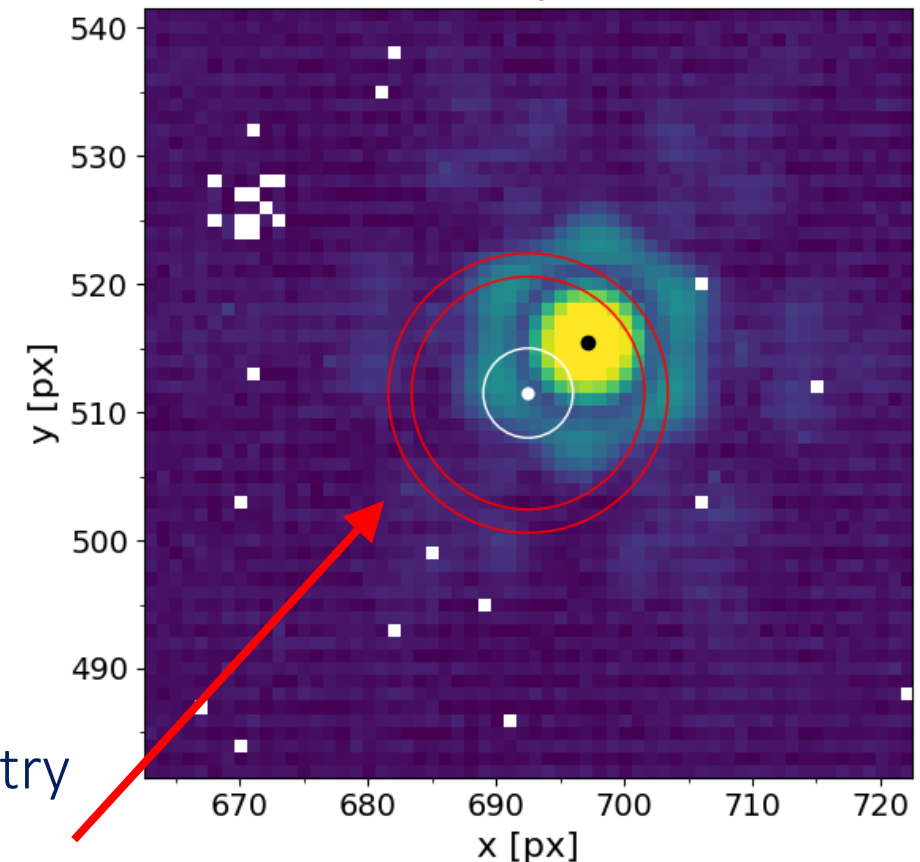


Taylor Bell



Melanie Clarke

PID 01177, Obs 007



Old TSO photometry aperture and background annulus



Highlight: $1/f$ improvements

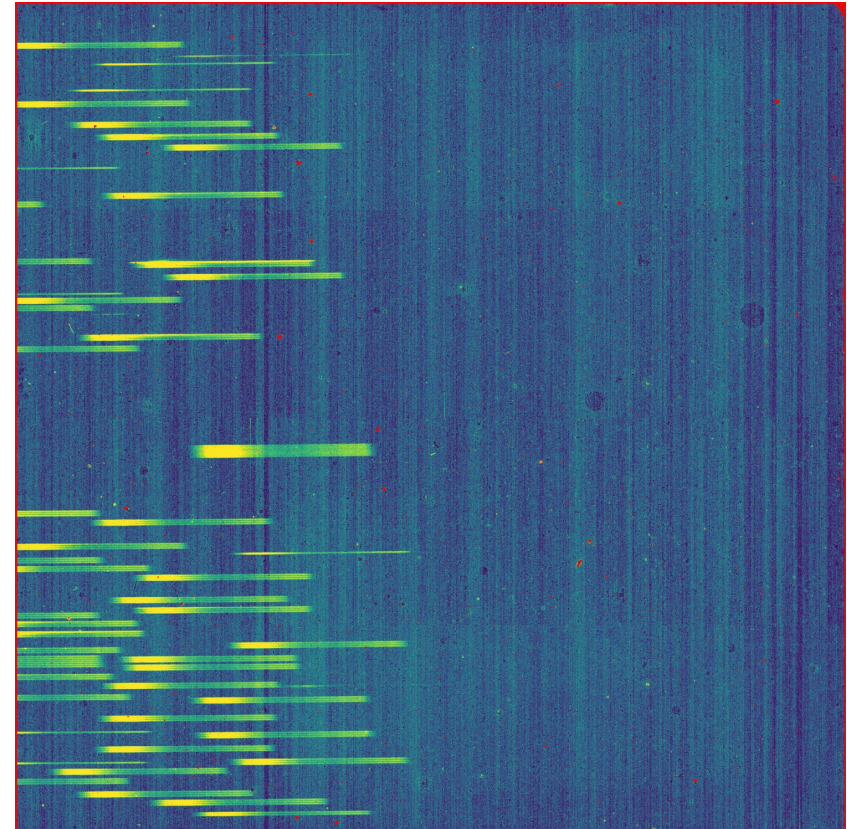


Bernie Rauscher

Clean_flicker_noise step has been available since build 11.1 (Sep 2024) to correct $1/f$ noise, but is not on by default (science scene dependent).

Build 12.0 improves $1/f$ for all NIR instruments using the Simple Improved Reference Subtraction (SIRS) method.

- B. Rauscher (GSFC) determined optimal reference pixel kernels for all NIR detectors.
- Correction does not depend on scene; default for NIRCams and NIRSpec (non-IRS² readouts).
- Moderate improvement in $1/f$ noise.





Highlight: 1/f improvements



Paul Goudfrooij

Clean_flicker_noise step has been available since build 11.1 (Sep 2024) to correct 1/f noise, but is not on by default (science scene dependent).

Build 12.1 adds automatic configuration of clean_flicker_noise step for NIRCam imaging, NIRCam WFSS, NIRISS imaging. Developed by P. Goudfrooij.

- Automatically assesses scene and determines best step configuration.
- Corrects 1/f noise well in all tested data
- Intend to use this to enable 1/f correction by default for these modes in 12.3



Highlight: NIRSpec IFU improvements



Melanie Clarke

Revised WCS architecture to use slice masks similar to MIRI MRS:

- User interaction is much simpler; transform easily from pixels to sky:

```
model.meta.wcs.transform('detector', 'world', 77, 809)
```

- Runtime for multiple stages of NIRSpec IFU pipeline improves as a result
- Cube building for 2 detectors and 4 exposures decreases from 4 minutes to 1.5 minutes.



Highlight: NIRSpec IFU improvements

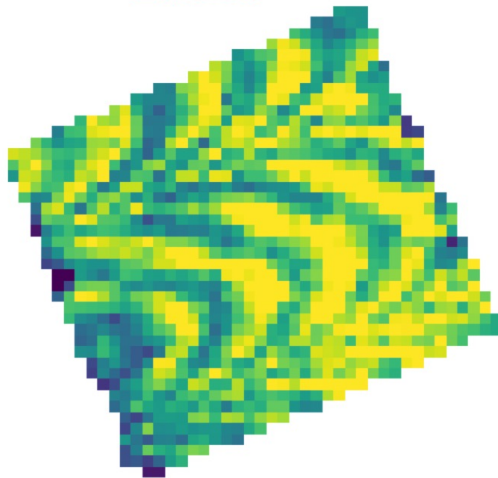


Jane Morrison

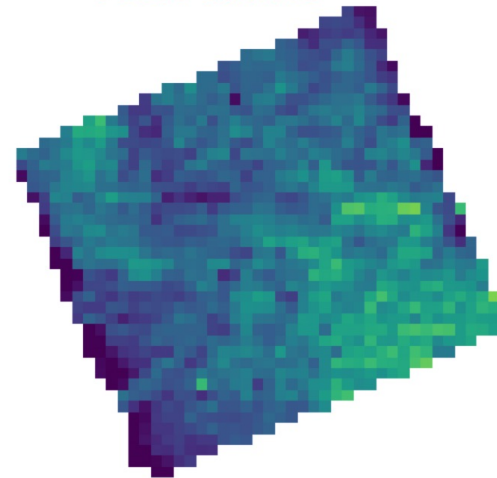
Added support for non-linear wavelength solutions for NIRSpec prism data cubes

- Detector sampling is strongly non-linear, resulting in artifacts in linear cubes
- Plan to make non-linear cubes default for prism in 12.3

Linear



Non-linear

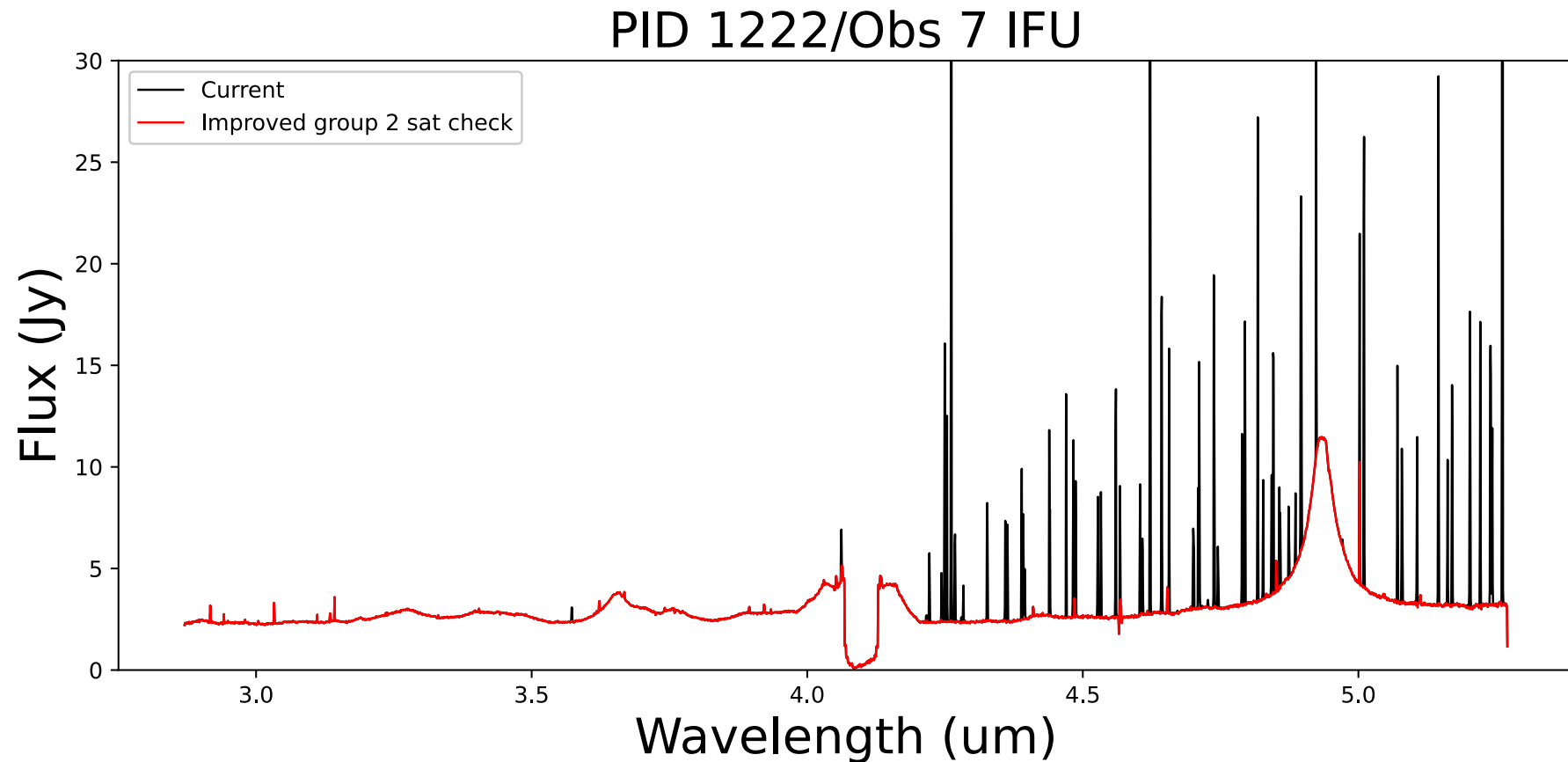


Cube slices centered on extended line emission suffer significant resampling artifacts when using linear sampling



Highlight: NIRSpec IFU improvements

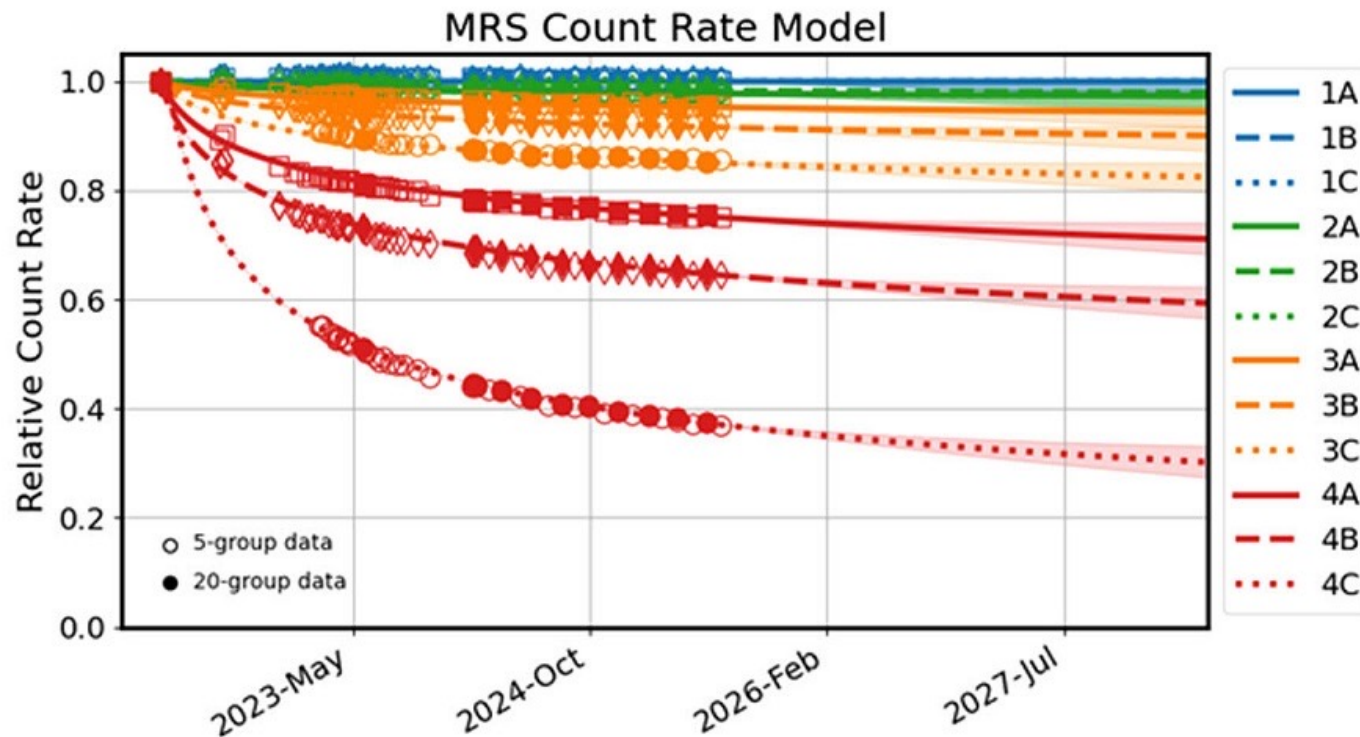
Identified and flagged breakthrough cosmic rays and bad pixels, which reduces outliers in NIRSpec IFU on top of previous improvements:





Highlight: MIRI Time-Dependent Throughput Corrections

Additional observations show that the decrease in MIRI count rates deviates from the exponential model previously used to correct MIRI flux calibrations. More complex models are now supported in the pipeline and enable updated corrections.

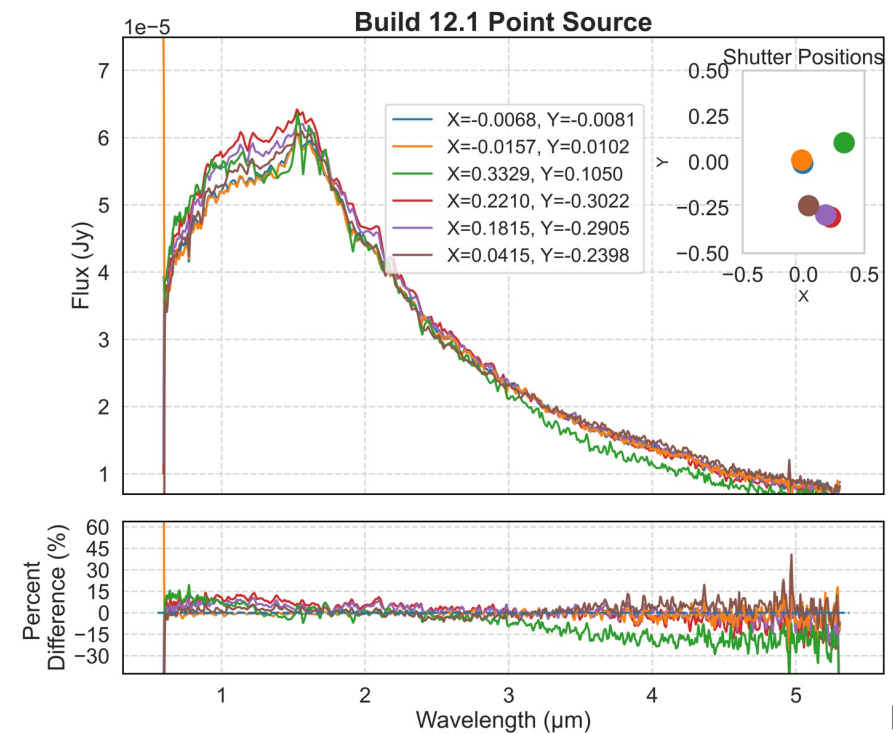
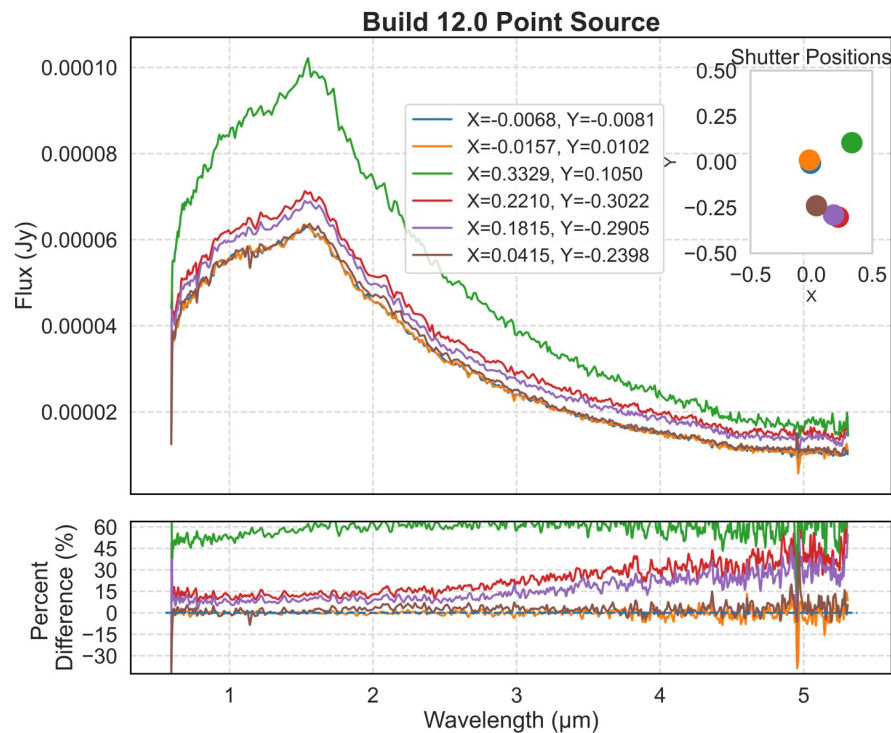




Highlight: MOS Calibration improvements

MOS slit-loss calibration has improved flux calibration for off-center point sources (reduces scatter in spectra from different shutter positions from $\sim 70\%$ to $\sim 15\%$ across the open shutter area)

Example of calibration work done by instrument teams outside of JP development that can be needed to address common user issues.





Supporting the user community: Pipeline notebooks



JWST Pipeline Notebooks

Notebooks all follow a streamlined, end-to-end workflow

Designed to be easy to adapt for individual science programs (with demo data to get started).

Commented-out code throughout showing how to modify key pipeline parameters.

16 observing modes now have notebooks (3 new since March)

Citable via Zenodo DOI

DOI 10.5281/zenodo.17195968

Instrument	Observing Mode	JWST Build	jwst version	Notebook
MIRI	Coronagraphy	12.0	1.19.1	JWPipeNB-MIRI-Coron.ipynb
MIRI	Imaging	12.0	1.19.1	JWPipeNB-MIRI-imaging.ipynb
MIRI	Imaging TSO	12.0	1.19.1	JWPipeNB-MIRI-imaging-TSO.ipynb
MIRI	LRS Slit	12.0	1.19.1	JWPipeNB-MIRI-LRS-slit.ipynb
MIRI	LRS Slitless	12.0	1.19.1	JWPipeNB-MIRI-LRS-slitless-TSO.ipynb
MIRI	MRS	12.0	1.19.1	JWPipeNB-MIRI-MRS.ipynb
NIRCam	Coronagraphy	12.0	1.19.1	JWPipeNB-nircam-coronagraphy.ipynb
NIRCam	Imaging	12.1	1.20.0	JWPipeNB-nircam-imaging.ipynb
NIRISS	AMI	12.0	1.19.1	JWPipeNB-niriss-ami.ipynb
NIRISS	Imaging	12.0	1.19.1	JWPipeNB-niriss-imaging.ipynb
NIRISS	SOSS	12.1	1.20.2	JWPipeNB-niriss-soss.ipynb
NIRISS	WFSS	12.0	1.19.1	JWPipeNB-niriss-wfss.ipynb
NIRSpec	BOTS	12.0	1.19.1	JWPipeNB-NIRSpec-BOTS.ipynb
NIRSpec	Fixed Slit	12.0	1.19.1	JWPipeNB-NIRSpec-FS.ipynb
NIRSpec	IFU	12.0	1.19.1	JWPipeNB-NIRSpec-IFU.ipynb
NIRSpec	MOS	12.0	1.19.1	JWPipeNB-NIRSpec-MOS.ipynb



What are some issues that we working on now (build 12.3)?

- Implementing two new observing modes:
 - NIRCam DHS (Dispersed Hartmann Sensor). Uses only a small number of telescope segments to greatly improve bright limit ($J < 10.5$) for low-res slitless spectroscopy in the 1-2 μm range.
 - MIRI LRS Wide Field Slitless Spectroscopy
 - Progress in builds 12.0, 12.1, enable in 12.3.
- Corrections for undersampling artifacts in IFU data cubes
 - Method under study (Law+26 in prep), look for more details soon.
- Revise snowball handling to remove OpenCV (maintenance issue)
- Runtime improvements to NIRISS SOSS
 - 10+ hour runtimes for spectral extraction from long TSOs
- Persistence corrections: saturation artifacts impact future exposures
- NIRSpec thermal picture frame correction



Summary

- WFSS and TSO spectral file formats have undergone a major reorganization to improve the usability of these products
- The pipeline has been greatly improved in some areas (e.g., runtime), and multiple tools are available to provide users reprocessing options (1/f correction step, pipeline notebooks)
- Exploring ways to limit the need for user reprocessing: turning on 1/f corrections for some modes, applying WFSS contamination corrections, etc.
- Continuing to address common user issues
- Beginning to work on new development and long-term improvement for specific modes
- Users are encouraged to continue submitting any problems to the JWST help desk