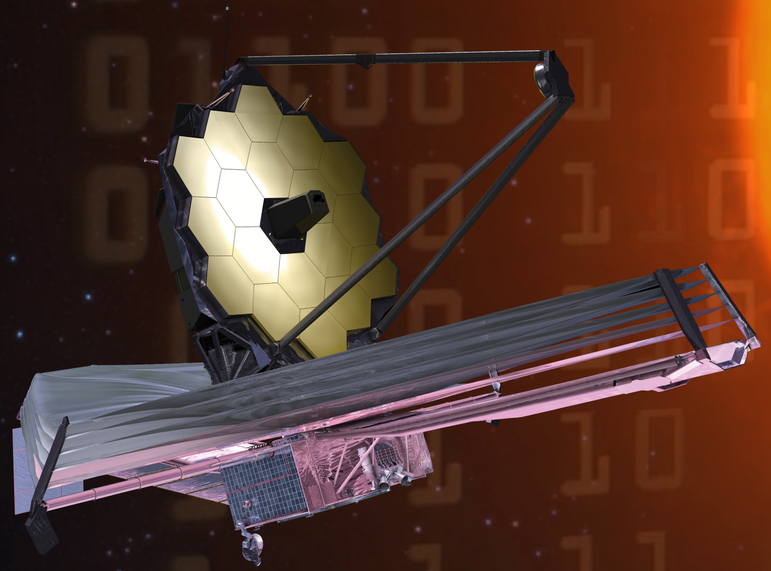


JWST DATA: WHAT DOES IT LOOK LIKE?
HOW TO CALIBRATE IT & WHAT TO EXPECT

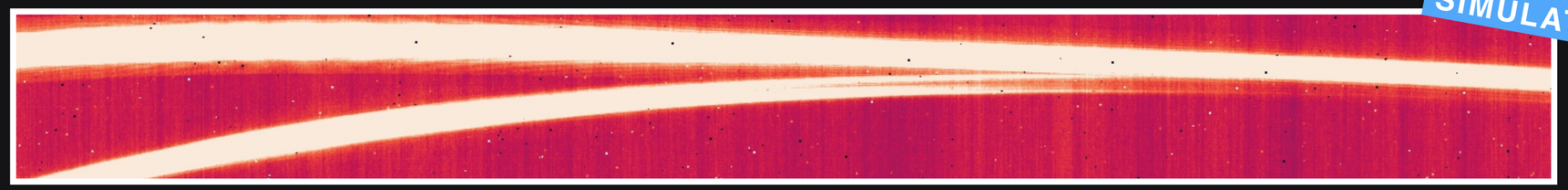
NÉSTOR ESPINOZA | STScI | SPACE TELESCOPE SCIENCE INSTITUTE

JWST DATA: WHAT DOES IT LOOK LIKE?

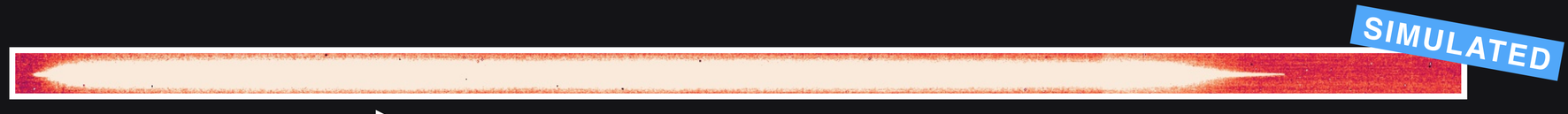
SPECTROSCOPIC

JWST DATA: WHAT DOES IT LOOK LIKE?

NIRISS



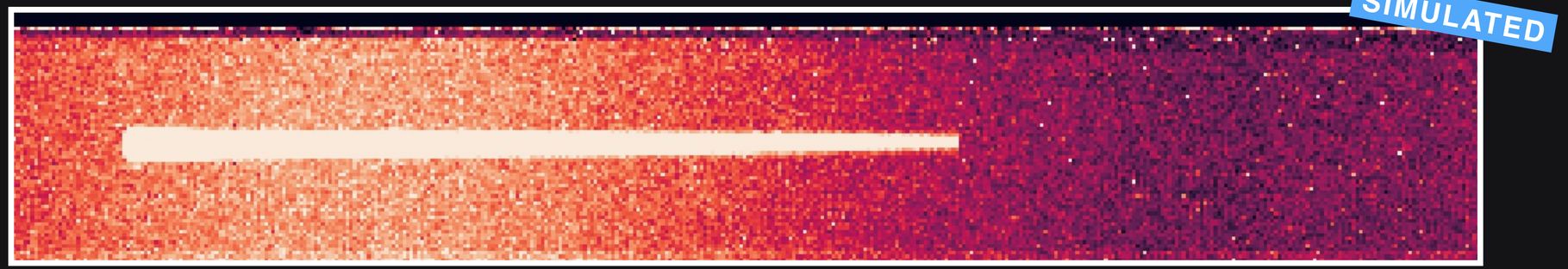
NIRCAM



WAVELENGTH

NIRSPEC

MIRI



LOOKS OVERWHELMING. HANG IN THERE!

AT THE END OF THIS TALK, YOU WILL:

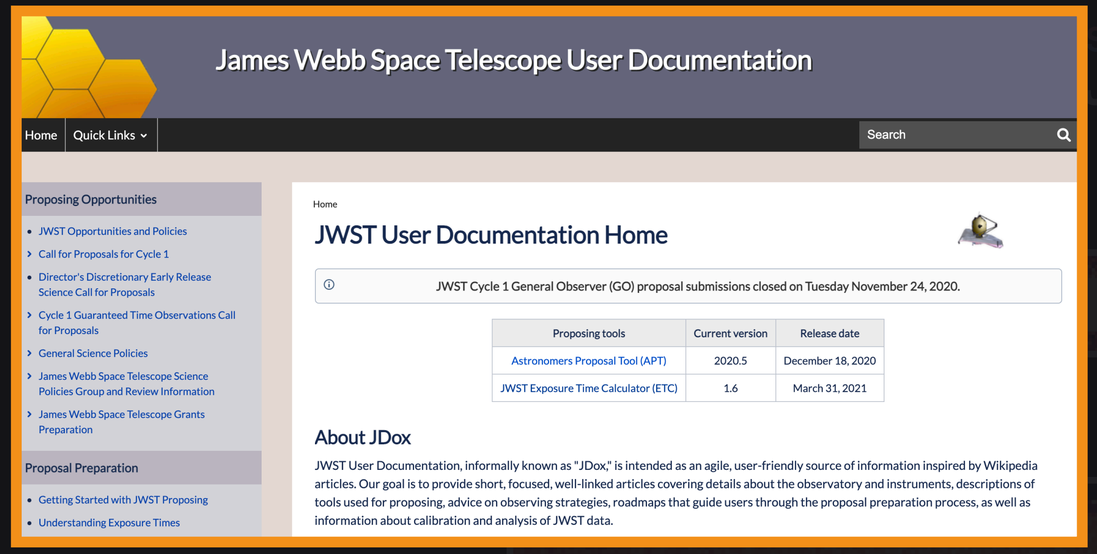
- UNDERSTAND THE DIFFERENCES (& SIMILARITIES) OF **JWST INSTRUMENTS & THEIR DATA**.

- **HOW TO CALIBRATE THIS DATA**; WHY THIS IS NEEDED.

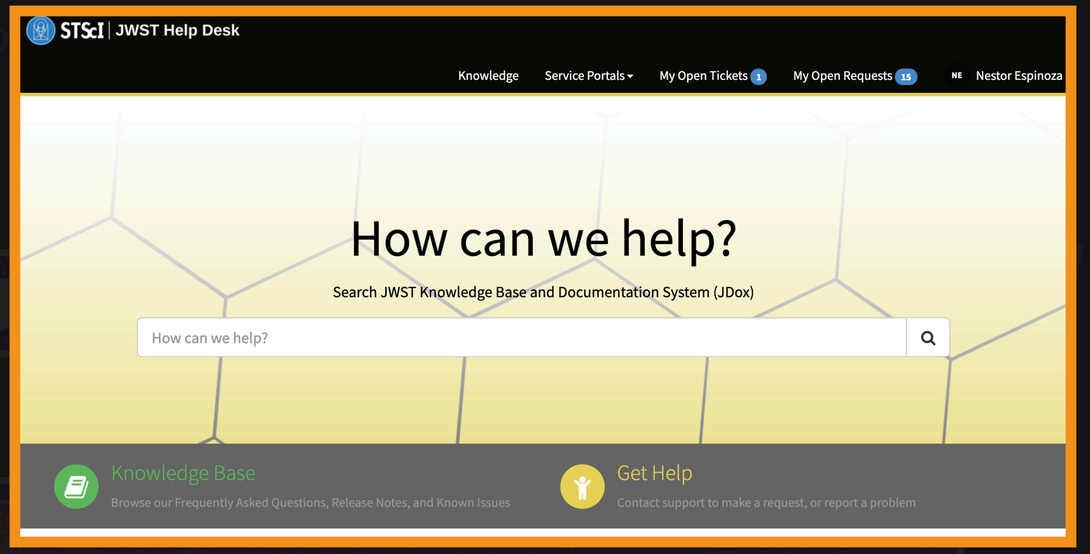
- WHAT ASPECTS OF THE CALIBRATION YOU SHOULD PAY ATTENTION TO IN ORDER TO **OPTIMIZE YOUR SCIENCE**.

IMPORTANT RESOURCES TO KEEP IN MIND

jwst-docs.stsci.edu



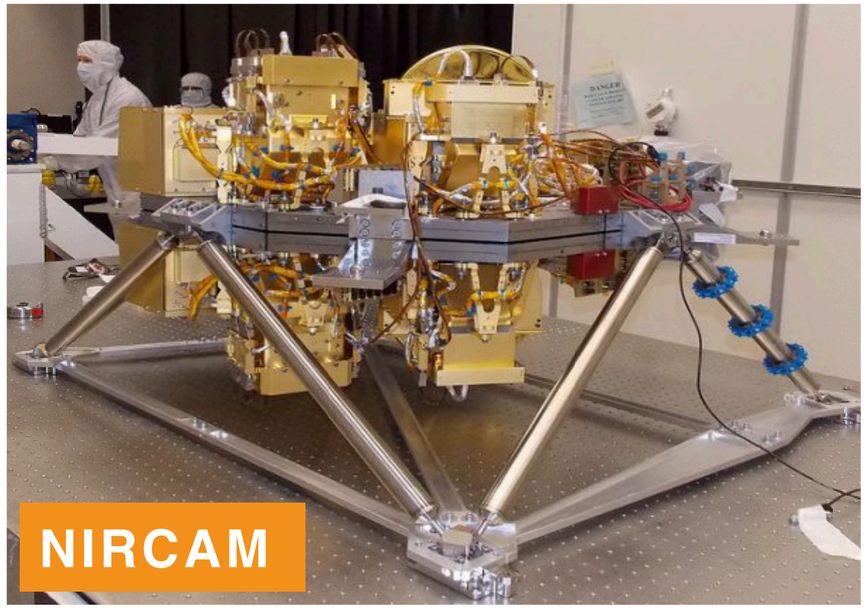
jwsthelp.stsci.edu



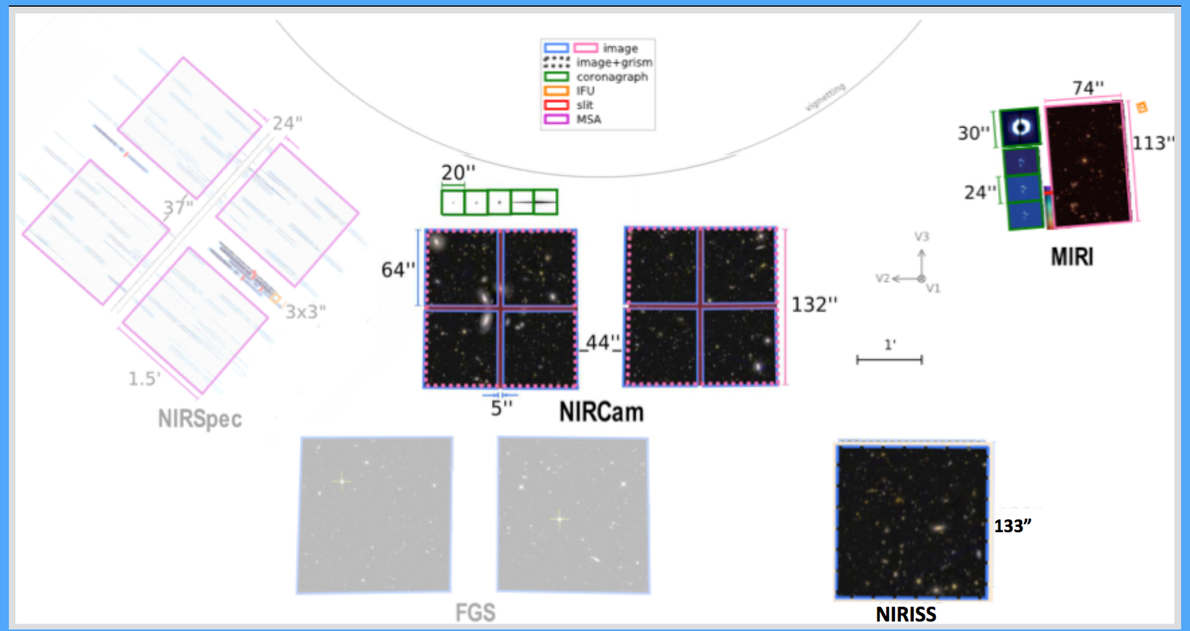
PART 1

KNOW THY INSTRUMENT, KNOW THY DATA

Image credit: Greenhouse (2015, SPIE Proc. Vol. 9602; 960202)



EACH INSTRUMENT HAS ITS OWN SPACE IN JWST



SPECTROSCOPY WITH

NIRSPEC

G140M/H

G235/H

G395M/H

PRISM

0.6 1.0 2.0 3.0 4.0 5.0

SOSS

F322W2

F444W

NIRISS

NIRCAM

*MRS1

*MRS2

*MRS3

*MRS4

5.0 7.7 11.9 18.4 28.0

LRS

*WITH AN INTEGRAL FIELD UNIT (IFU)

MIRI

SPECTROSCOPY WITH

NIRSPEC

NIR INSTRUMENTS
(HAWAII-2RG, HgCdTe DETECTORS)

G140M/H G235/H G395M/H PRISM

0.6 1.0 3.0 5.0

WHAT YOU'LL LEARN HERE

(E.G. SIMILAR DETECTORS)

SOSS F444W F322W2

NIRISS NIRCAM

MRS1 MRS2 MRS3 MRS4

IR INSTRUMENTS
(Si:As IBC DETECTORS)

5.0 7.7 11.0 18.4 28.0

WON'T NECESSARILY TRANSLATE HERE

LRS

MIRI

PART 2

HOW TO CALIBRATE THE DATA: JWST PIPELINE(S)

DISCLAIMER/PREDICTION:

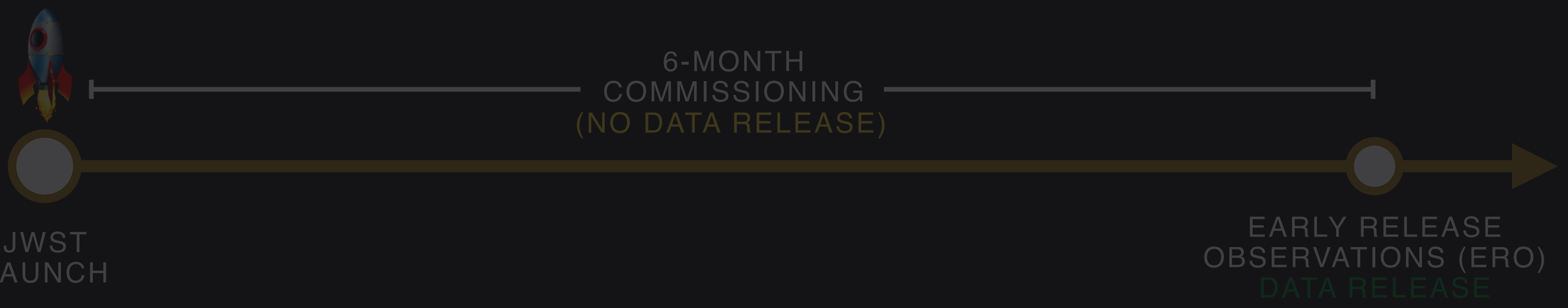
THERE WILL **NOT** BE A **PERFECT PIPELINE**

(AT LEAST AT THE BEGINNING)

DISCLAIMER/PREDICTION:

THERE WILL **NOT** BE A **PERFECT PIPELINE**

(AT LEAST AT THE BEGINNING)



JWST IS DIFFERENT TO OTHER MISSIONS:

DATA PROVIDED RIGHT AWAY

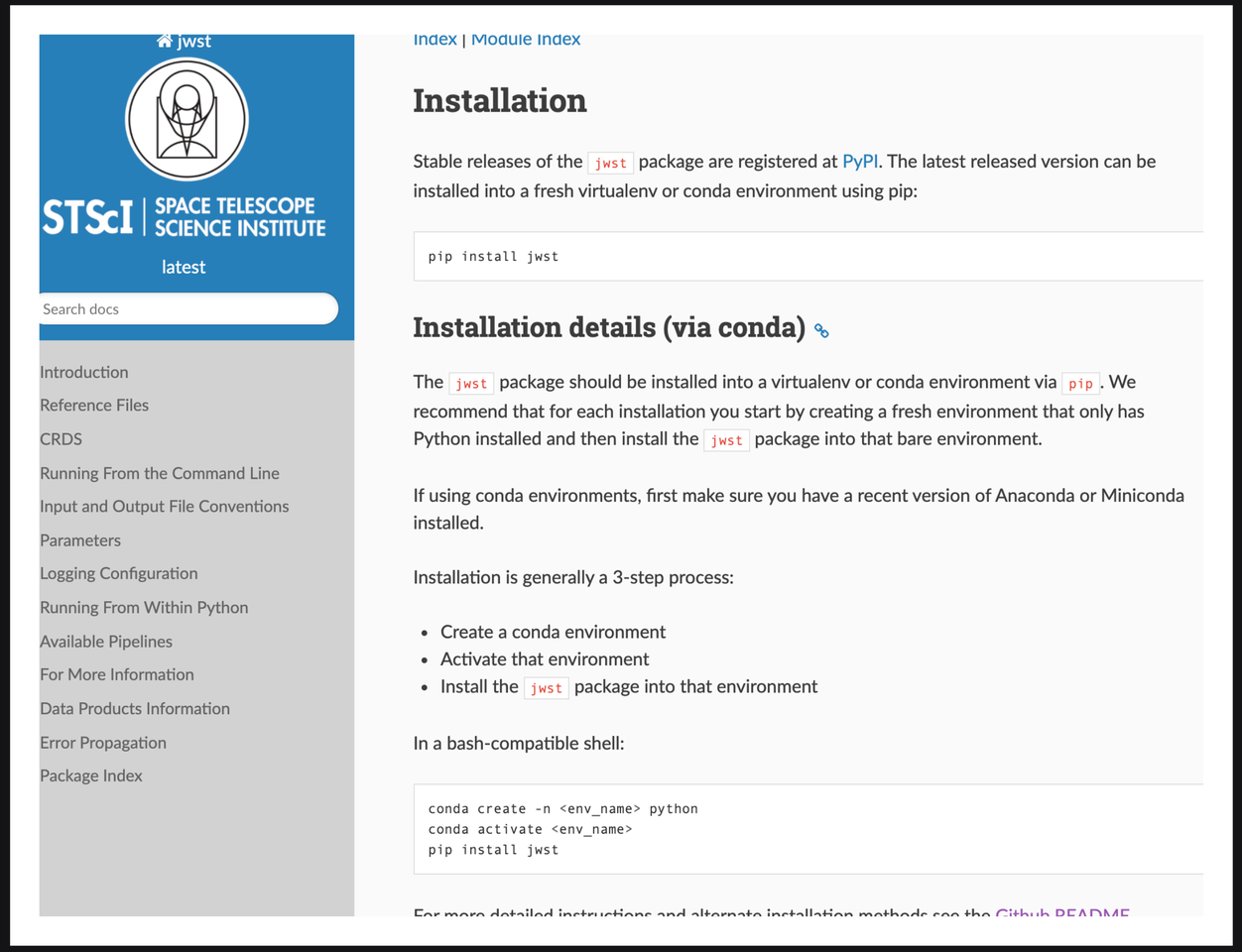
(AFTER COMISSIONING)

PRO: COMMUNITY HAS QUICK ACCESS TO DATA

CON: NO PIPELINE WILL BE PERFECT RIGHT AWAY

THE JWST DATA REDUCTION PIPELINE

jwst-pipeline.readthedocs.io



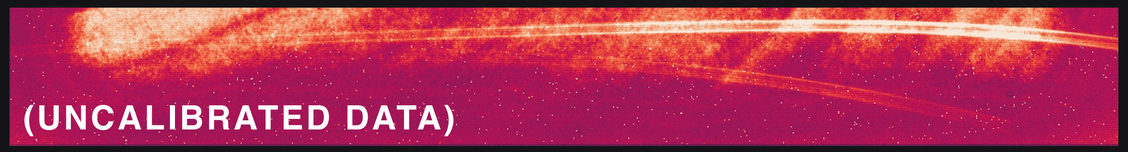
- Really, *a* JWST pipeline.
- Coded in **Python.** **Modular.** Open source.
- Algorithms tailored to particular instruments and modes.
- Has direct input from JWST instrument teams.
- Currently under active development at STScI.

*TSO: Time-Series Observation

THE JWST DATA REDUCTION PIPELINE

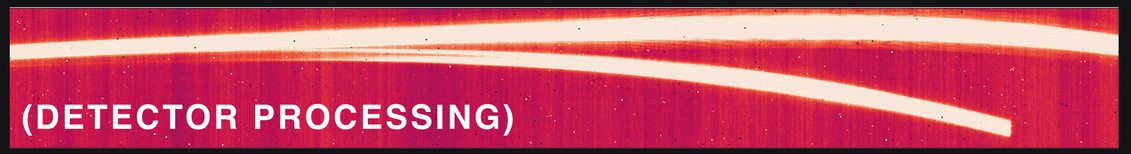
The calibration pipeline is divided into Stages. For *TSOs:

STAGE 0:

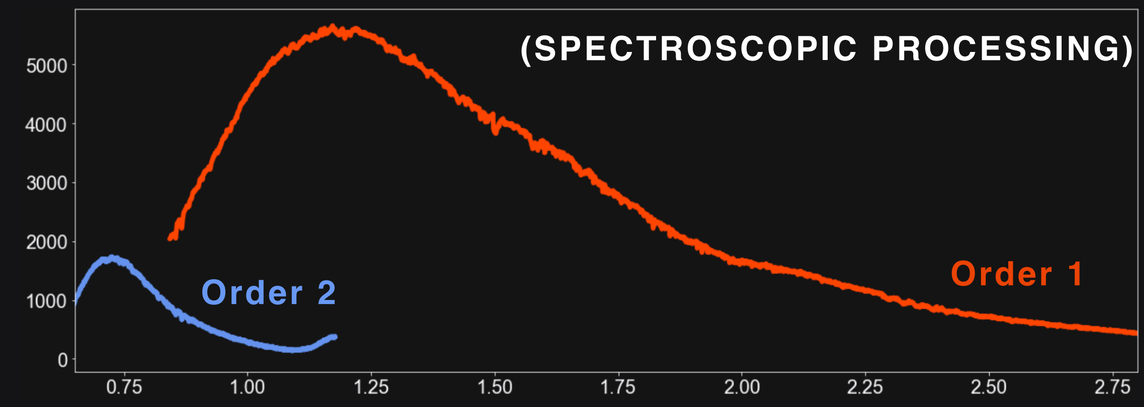


Simulated uncalibrated (*.uncal.fits) NIRISS/SOSS data

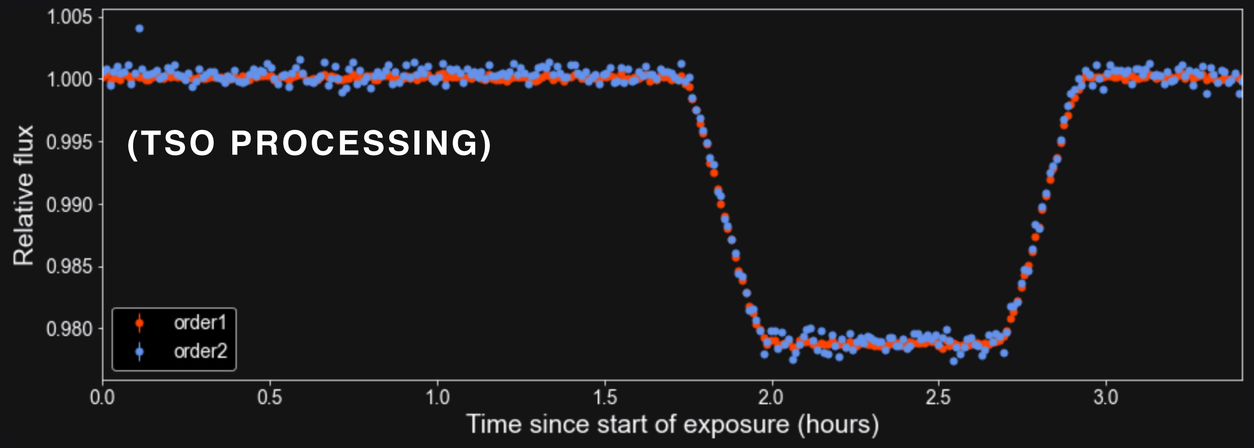
AFTER STAGE 1:



AFTER STAGE 2:



AFTER STAGE 3:



*TSO: Time-Series Observation

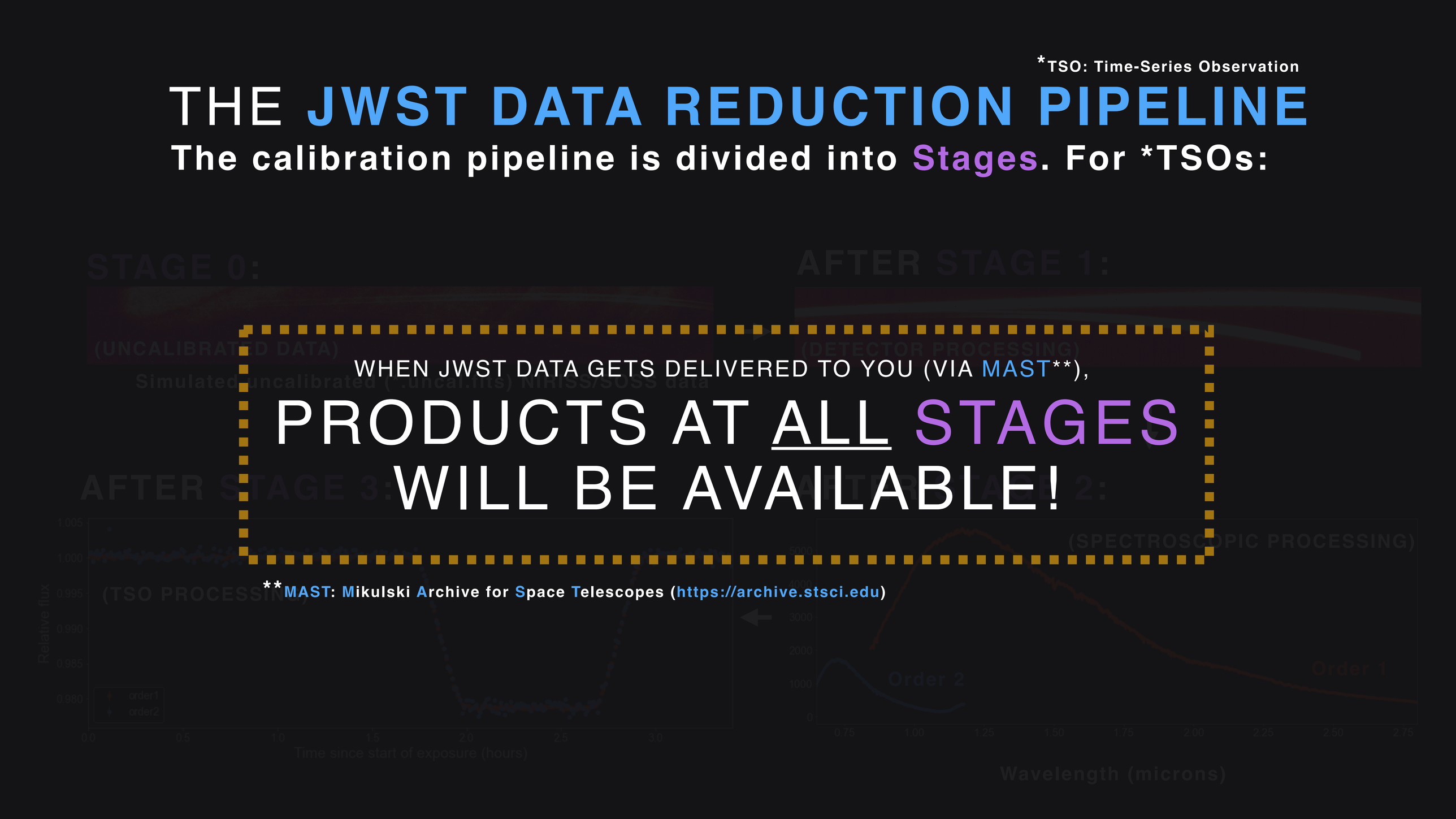
THE JWST DATA REDUCTION PIPELINE

The calibration pipeline is divided into Stages. For *TSOs:

WHEN JWST DATA GETS DELIVERED TO YOU (VIA MAST**),

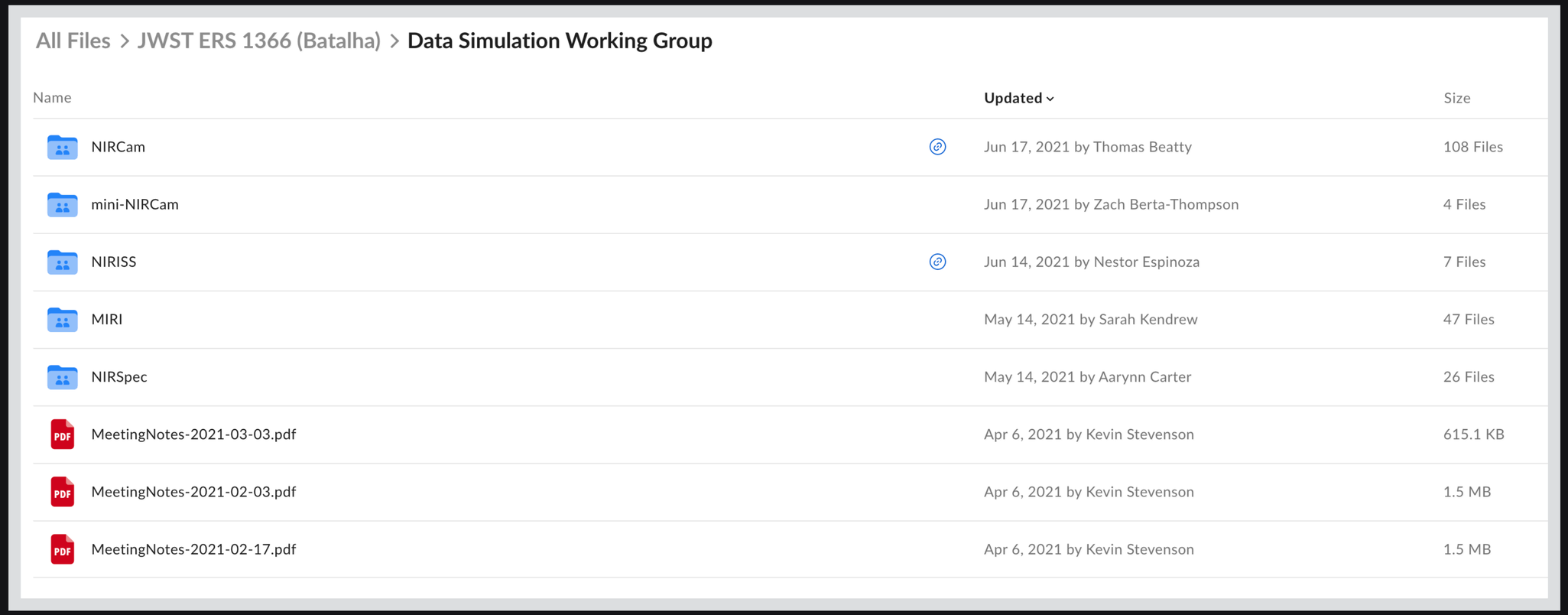
PRODUCTS AT ALL STAGES WILL BE AVAILABLE!

**MAST: Mikulski Archive for Space Telescopes (https://archive.stsci.edu)



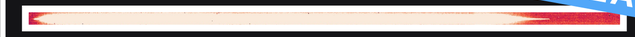
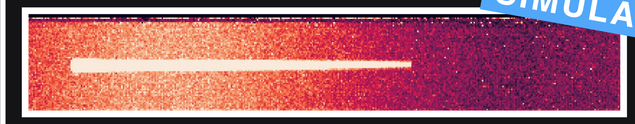
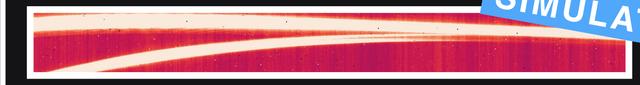
THE SIMULATED ERS DATASETS

HTTPS://ERS-TRANSIT.GITHUB.IO/PRE-LAUNCH-HACKATHON.HTML#DATA-AND-COMPUTING



THE SIMULATED ERS DATASETS

(Nintegrations, Ngroups, Pixel, Pixel)
(Nintegrations, Pixel, Pixel)
(Nintegrations, Pixel)

	Astrophysical signal	STAGE 0? (*uncal.fits)	STAGE 1? (*rateints.fits)	STAGE 2? (*x1dints.fits)	STAGE 3?
NIRCAM SIMULATED 	Transit	✓	✓	✓	✗
MIRI SIMULATED 	Phase-curve slice (+SE)	✓	✓	✓	✗
NIRSPEC GROUND TESTING 	Transit	✓	✓	✓	✗
NIRISS SIMULATED 	Transit	✓	✓	✗	✗

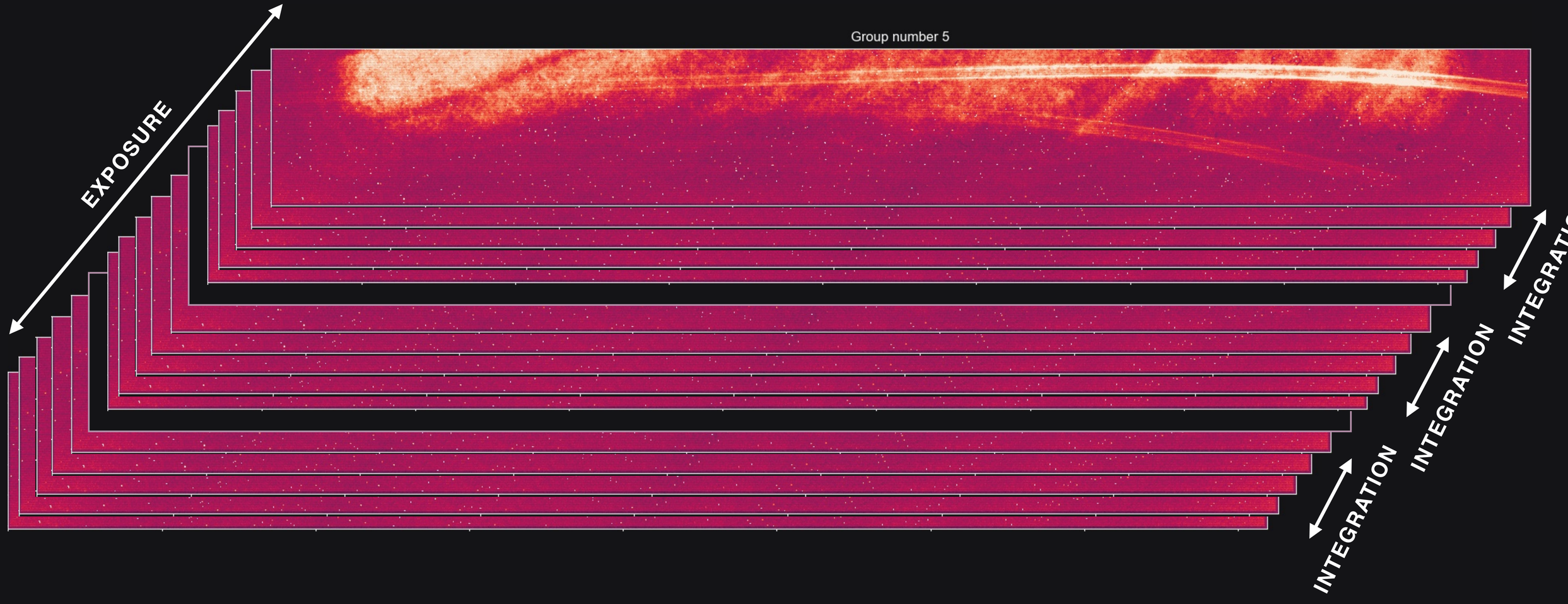
PART 3

HOW THE JWST PIPELINE WORKS, AND WHAT TO EXPECT

JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

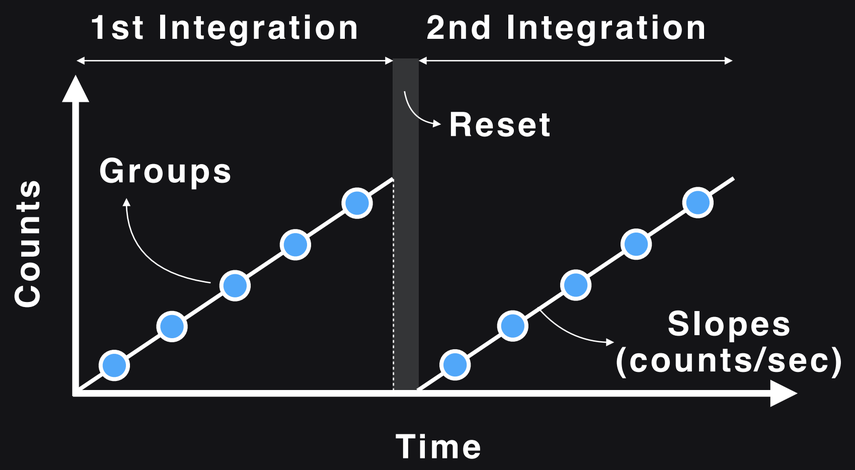


JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

A normal pixel

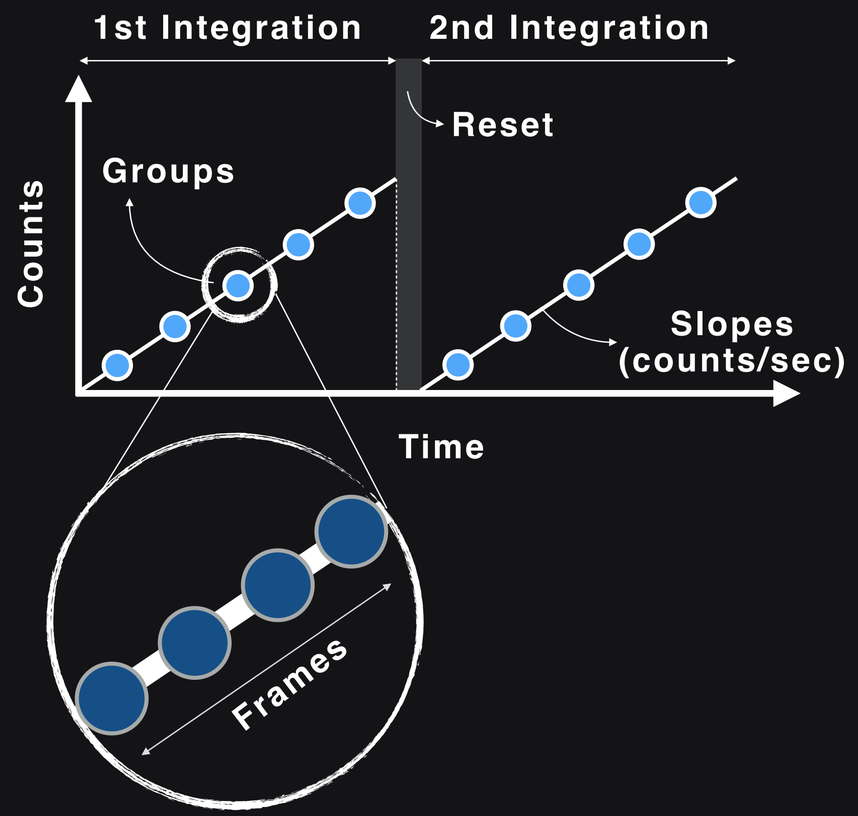


JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

A normal pixel

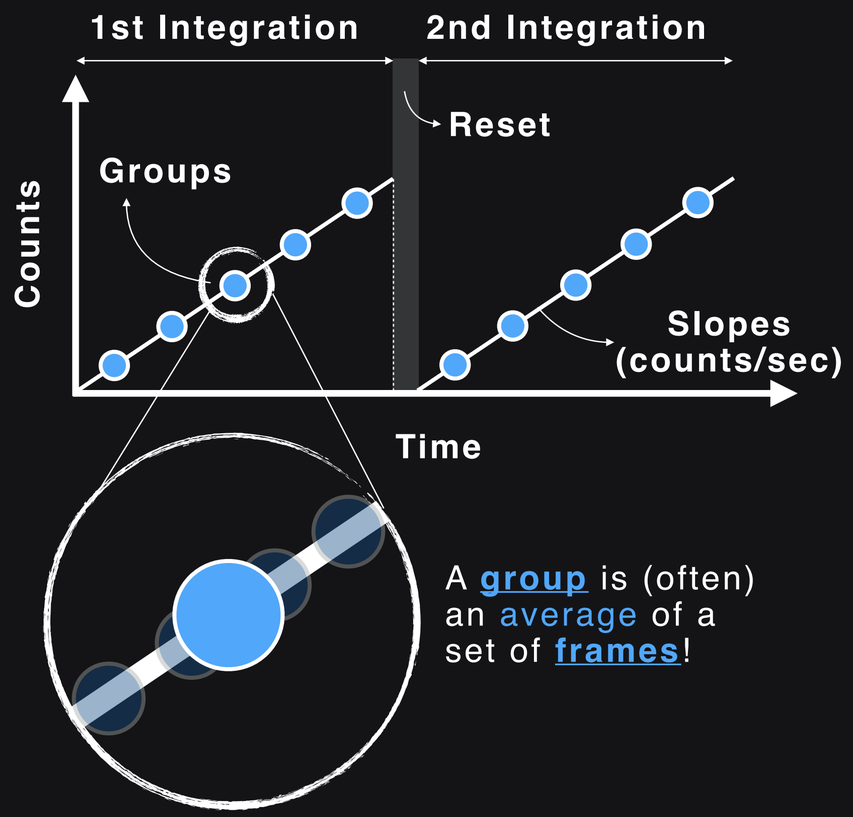


JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

A normal pixel



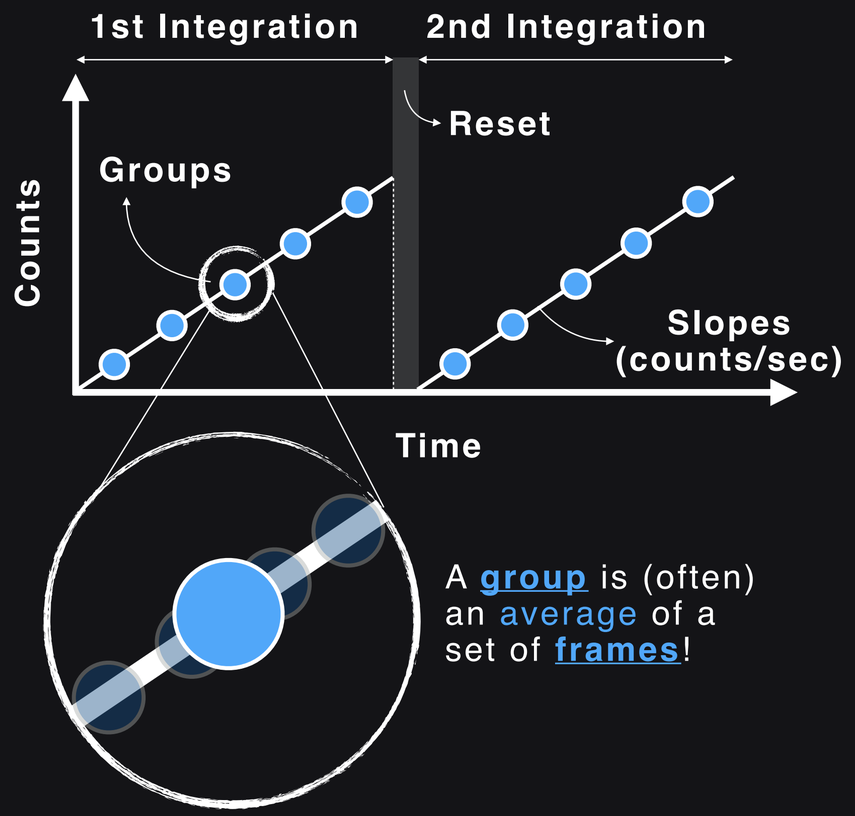
A **group** is (often) an average of a set of **frames**!

JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

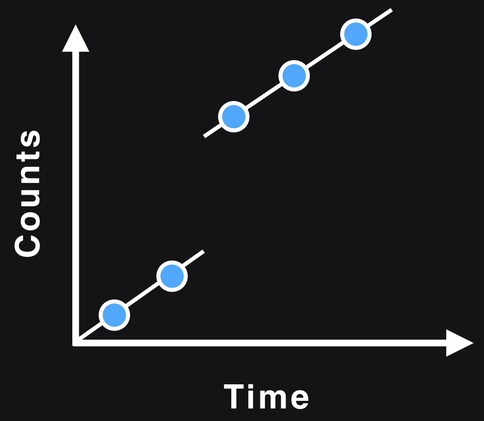
(a.k.a. MULTIACCUM)

A normal pixel



A **group** is (often) an average of a set of **frames**!

Pixel hit by CR



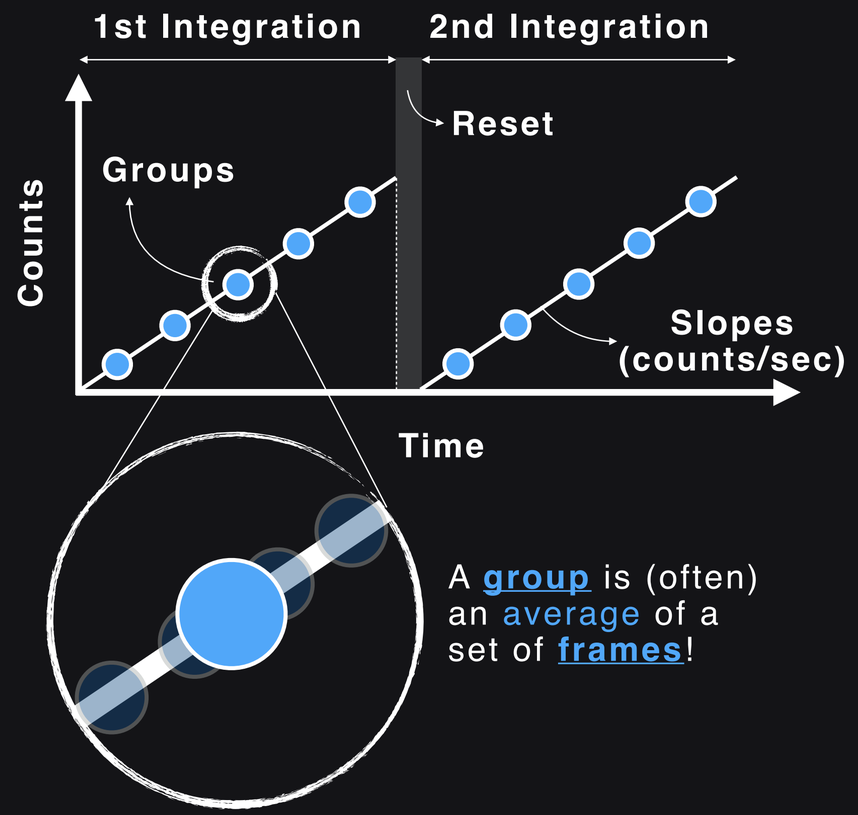
Cosmic rays can be modeled as “jumps” in an up-the-ramp sample.

JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

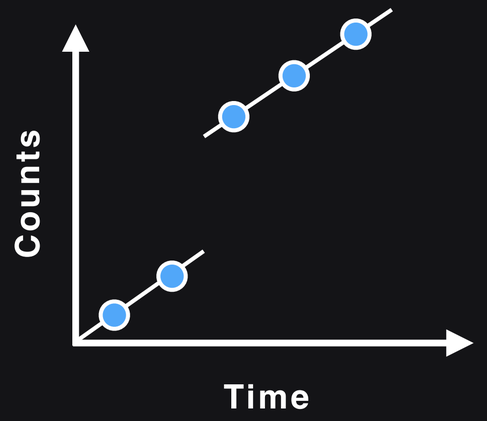
(a.k.a. MULTIACCUM)

A normal pixel



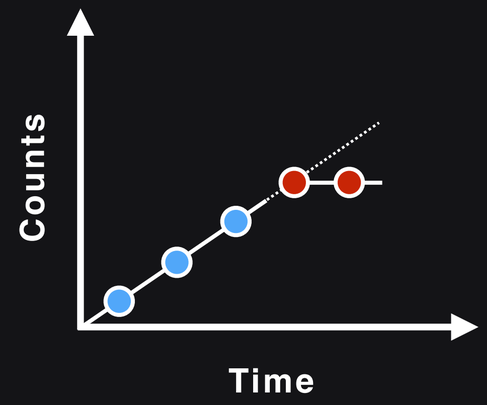
A **group** is (often) an average of a set of **frames**!

Pixel hit by CR



Cosmic rays can be modeled as “jumps” in an up-the-ramp sample.

Saturated pixel



Saturated pixels don’t “kill” your pixels. Can figure out slope with unsaturated groups.

THE JWST DATA REDUCTION PIPELINE

Stages go step-by-step

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

1st step

End step

Stage 1 steps

- Each **Stage** is composed of **steps**.
- Default **parameters/files** for each **step** come from **CRDS**:

jwst-crds.stsci.edu

JWST Calibration Reference Data System (CRDS)

Obtain Best Reference Files

1. Using the Command Line
2. From Dataset ID or FITS Header Upload
3. Exploring with Instrument Parameters

Reference File Database Services

1. Browse Database
2. Recent Activity

Operational References (under context jwst_0734.pmap)

- fgs
- miri
- nircam
- niriss
- nirspec
- system

Context History (more history, all contexts)

Start Date	Context	Status	Description
2021-06-18	jwst_0734.pmap	operational	New JWST NIRCam gain and photom reference files.
2021-06-03	jwst_0732.pmap	archived	Reverted the NIRCam specwcs rmap to an earlier version because the needed updates to use the specwcs reference files with FILTER as one of the selection criteria will not be ready for Build 7.8.
2021-05-28	jwst_0730.pmap	archived	Deliveries of initial rmaps for the whitelight parameter reference files for MIRI, NIRSpec, and NIRCam. Initial delivery of MIRI whitelight step parameter reference files. Update to NIRCam specwcs rmap to add FILTER as one of the selection criteria, and to return NA for a reference file for any pupil values other than GRISMR and GRISMC, and exposure types other than NRC_WFSS and NRC_TSGRISM. New NIRCam specwcs reference files.
2021-05-21	jwst_0723.pmap	archived	Updated rmaps for NIRCam flat, dark, and extract1d reference files. New MIRI extract1d reference file. New NIRISS tweakregstep and distortion reference files.

THE JWST DATA REDUCTION PIPELINE

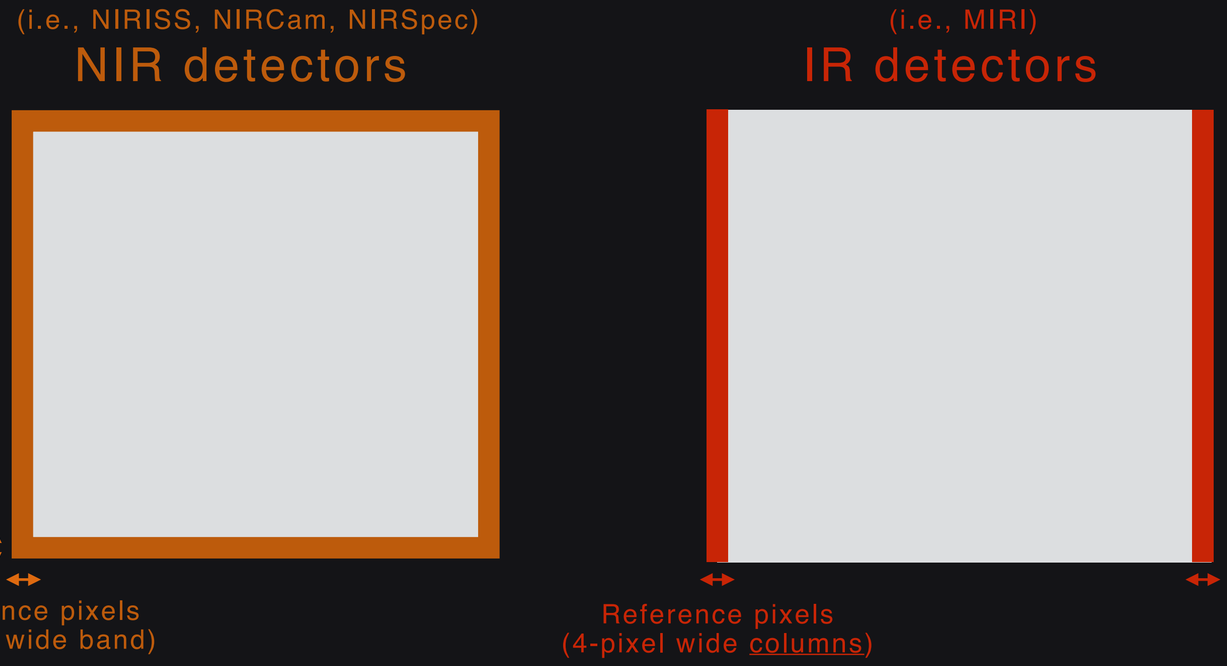
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:



THE JWST DATA REDUCTION PIPELINE

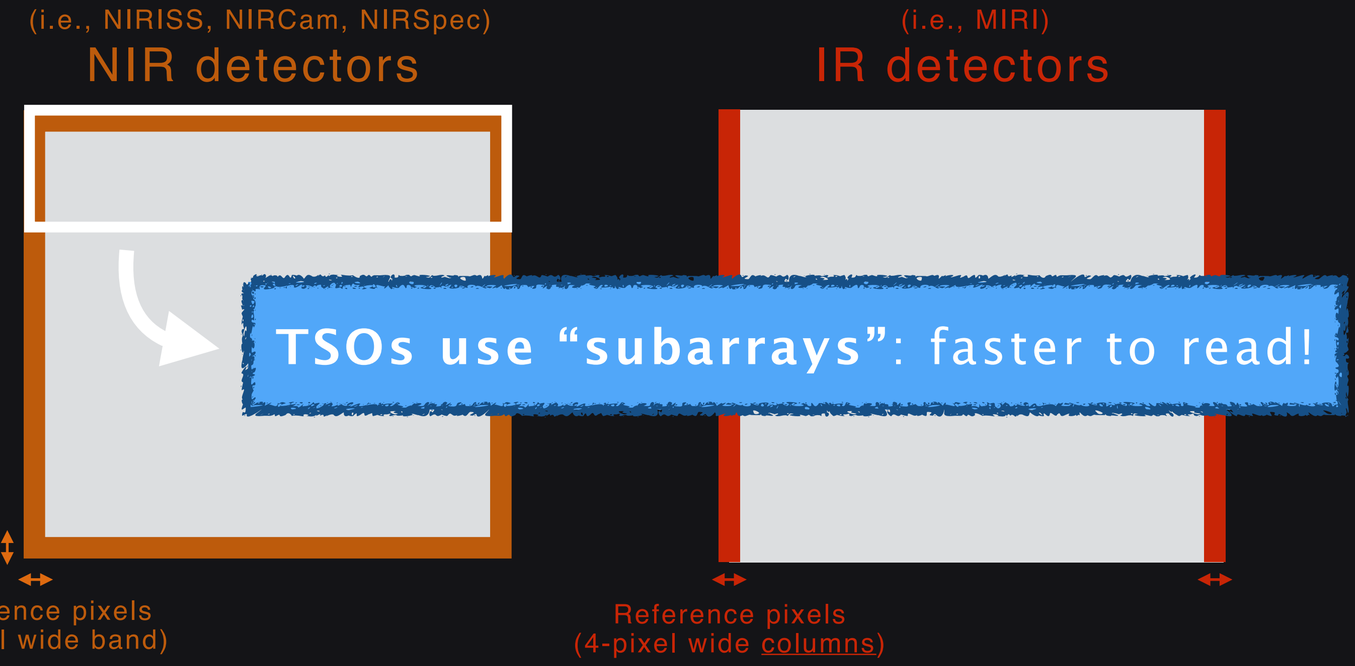
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:



THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
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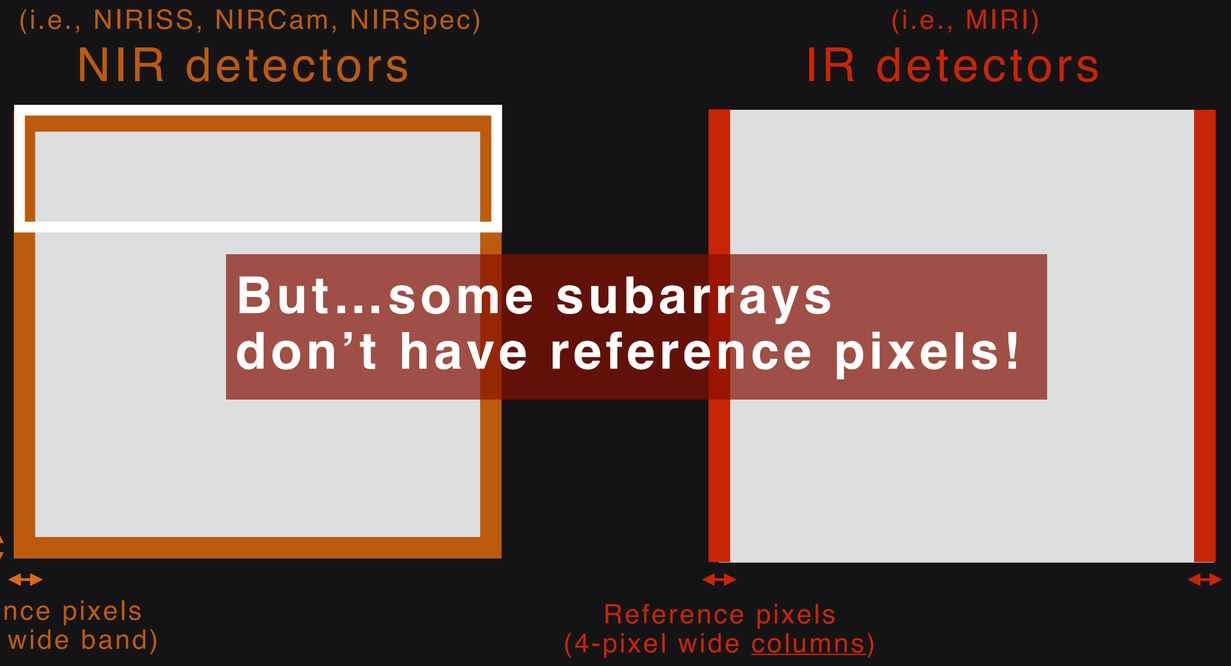
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:



THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
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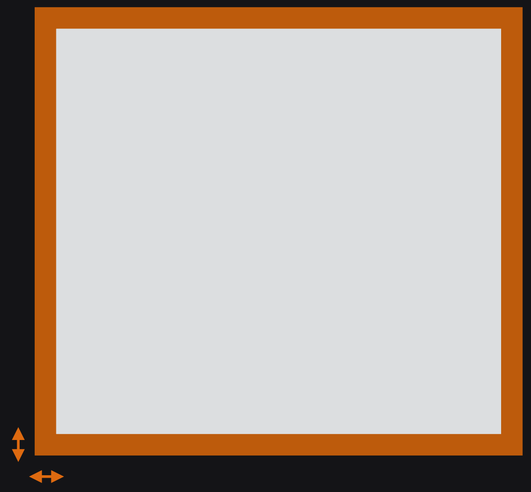
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:

(i.e., NIRISS, NIRCam, NIRSpec)

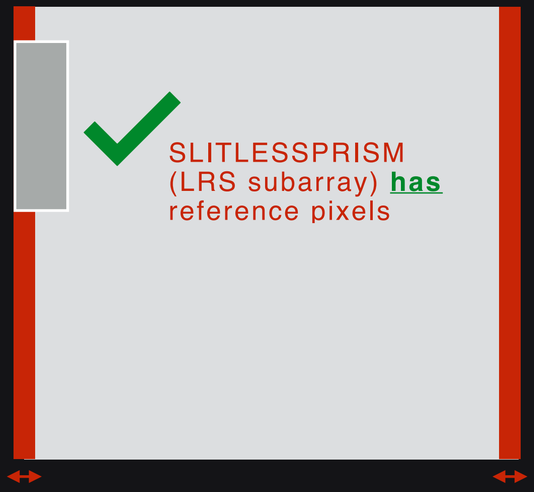
NIR detectors



Reference pixels (4-pixel wide band)

(i.e., MIRI)

IR detectors



Reference pixels (4-pixel wide columns)

THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

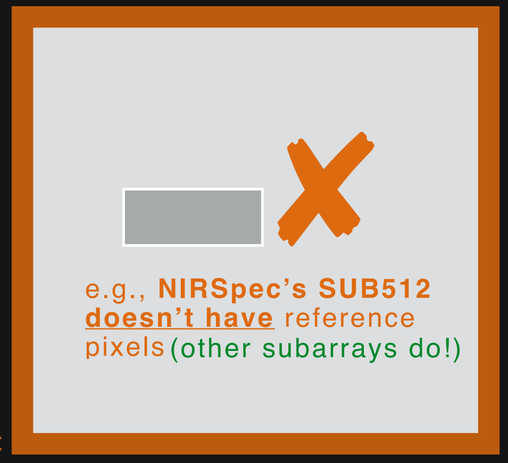
Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:

(i.e., NIRISS, NIRCam, NIRSpec)

NIR detectors

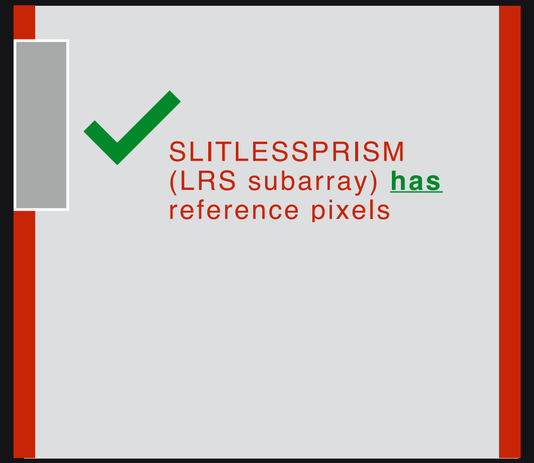


e.g., **NIRSpec's SUB512 doesn't have** reference pixels (other subarrays do!)

Reference pixels (4-pixel wide band)

(i.e., MIRI)

IR detectors



SLITLESSPRISM (LRS subarray) **has** reference pixels

Reference pixels (4-pixel wide columns)

THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

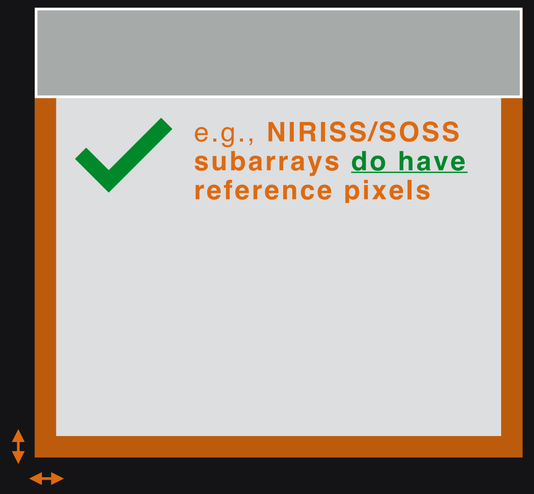
Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:

(i.e., NIRISS, NIRCam, NIRSpec)

NIR detectors



(i.e., MIRI)

IR detectors

THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

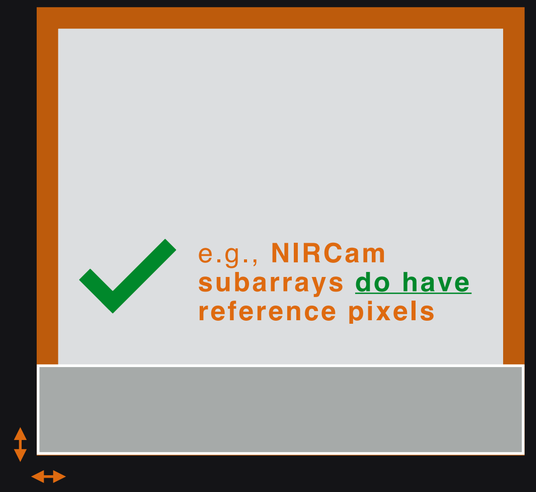
Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:

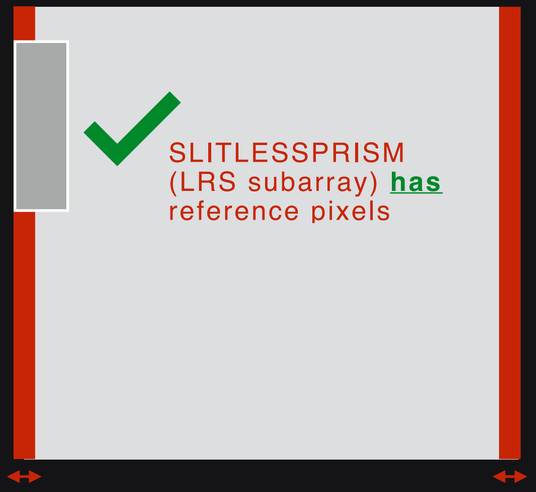
(i.e., NIRISS, NIRCam, NIRSpec)

NIR detectors



(i.e., MIRI)

IR detectors



THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:

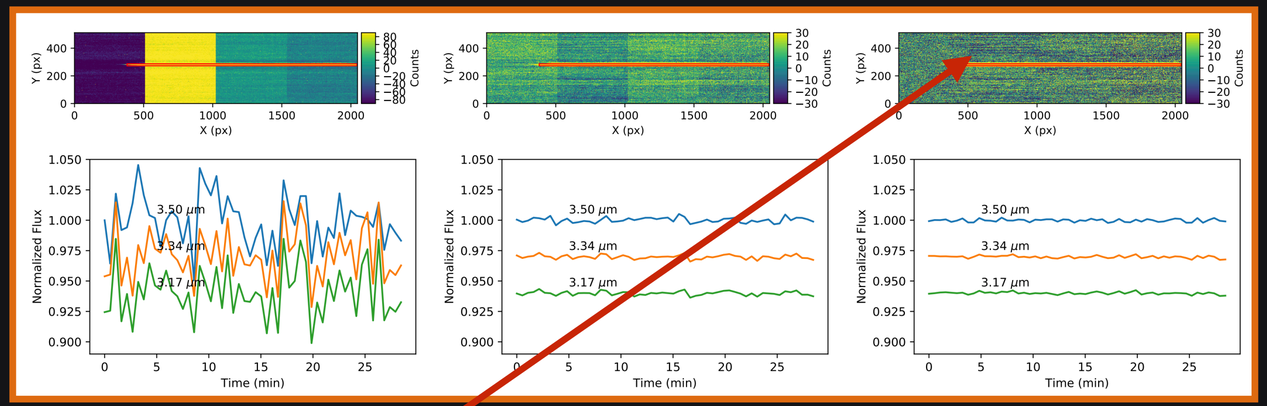


Image credit: Schlawin 2020, AJ, 160, 231

"1/f" noise (see Schlawin 2020, AJ, 160, 231)

THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

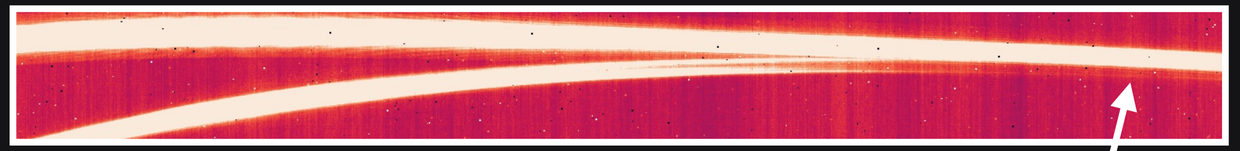
jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:

NIRISS AFTER STAGE 1



NIRSPEC SUB512 DATA AFTER STAGE 1

“1/f” noise (see Schlawin 2020, AJ, 160, 231)

THE JWST DATA REDUCTION PIPELINE

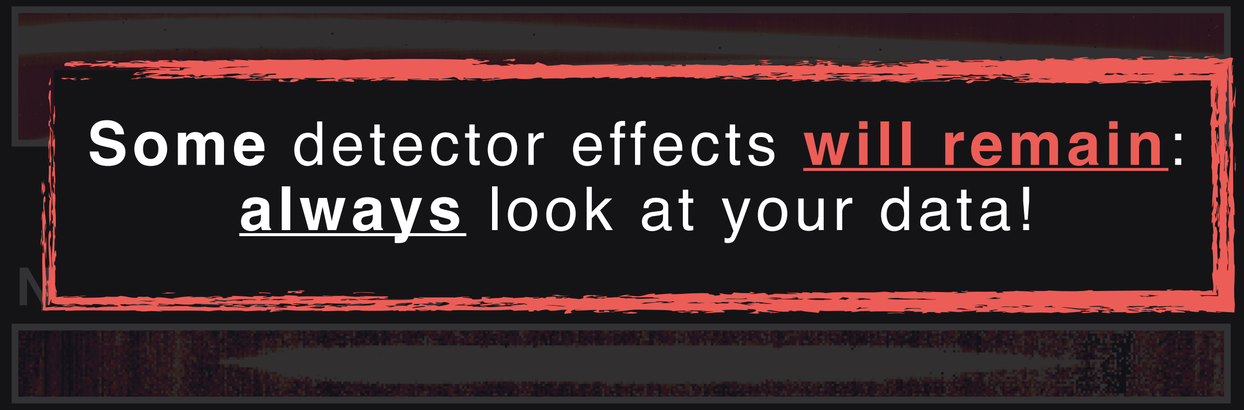
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **refpix** step aims to correct **detector variations using reference pixels**:



THE JWST DATA REDUCTION PIPELINE

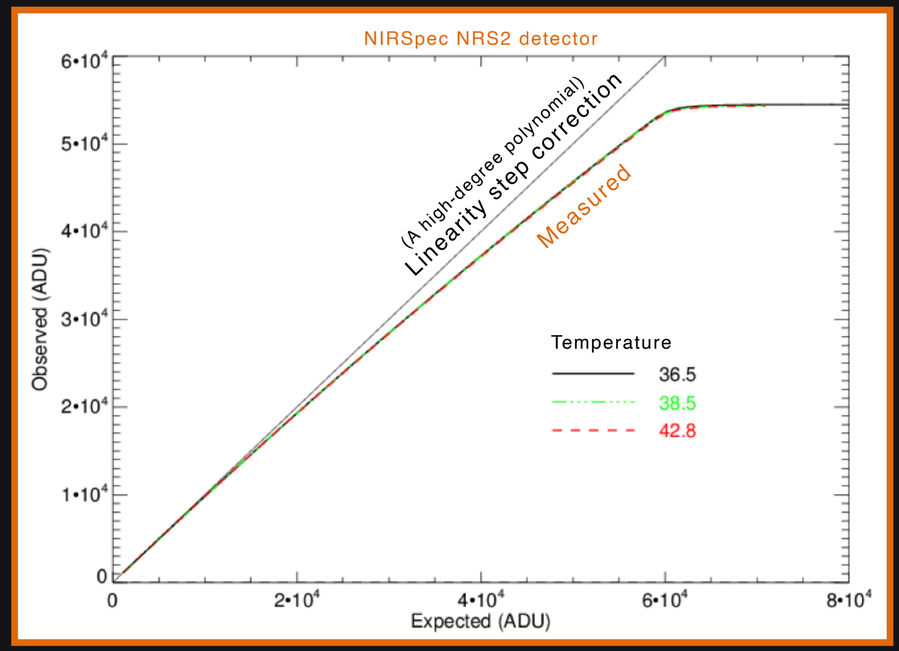
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **linearity** step aims to correct **detector non-linearity**:



THE JWST DATA REDUCTION PIPELINE

Stage 1 steps, and what to be on the lookout for

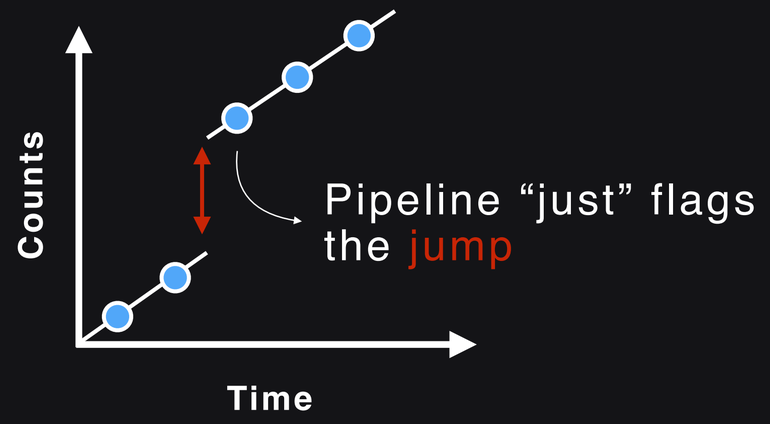
jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **jump*** step aims to detect jumps in the up-the-ramp samples:

Pixel hit by CR



*Only works for NGROUPS>2

THE JWST DATA REDUCTION PIPELINE

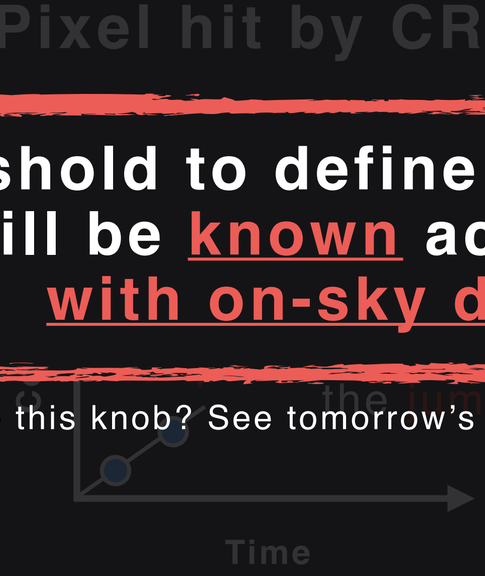
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **jump*** step aims to detect jumps in the up-the-ramp samples:



Threshold to define "what is a jump" will be known accurately only with on-sky data.

(How to change this knob? See tomorrow's talk and/or ReadTheDocs)

*Only works for NGROUPS>2

THE JWST DATA REDUCTION PIPELINE

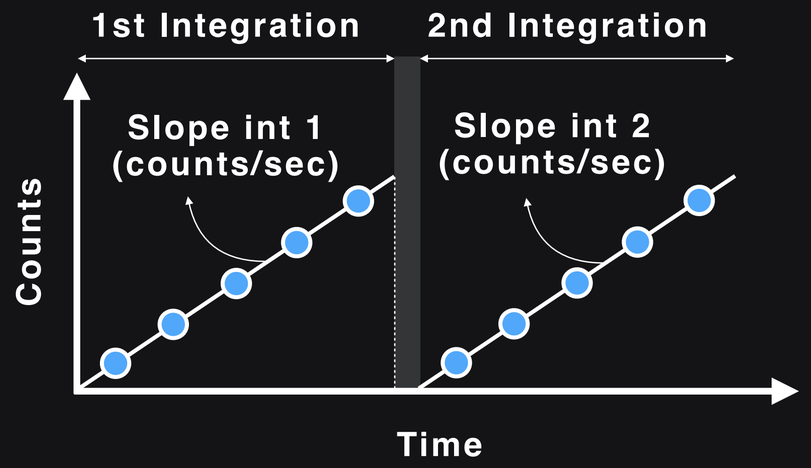
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **ramp_fitting** step obtains the slope on the up-the-ramp samples:



THE JWST DATA REDUCTION PIPELINE

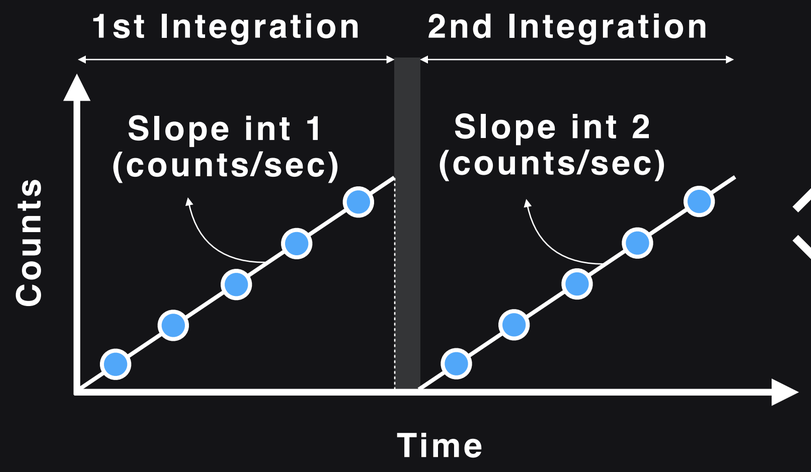
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

The **ramp_fitting** step obtains the slope on the up-the-ramp samples:



Average slope of exposure (i.e., the average image)

Slopes per integration (a.k.a, “rateint” products)

(What we typically want!)

THE JWST DATA REDUCTION PIPELINE

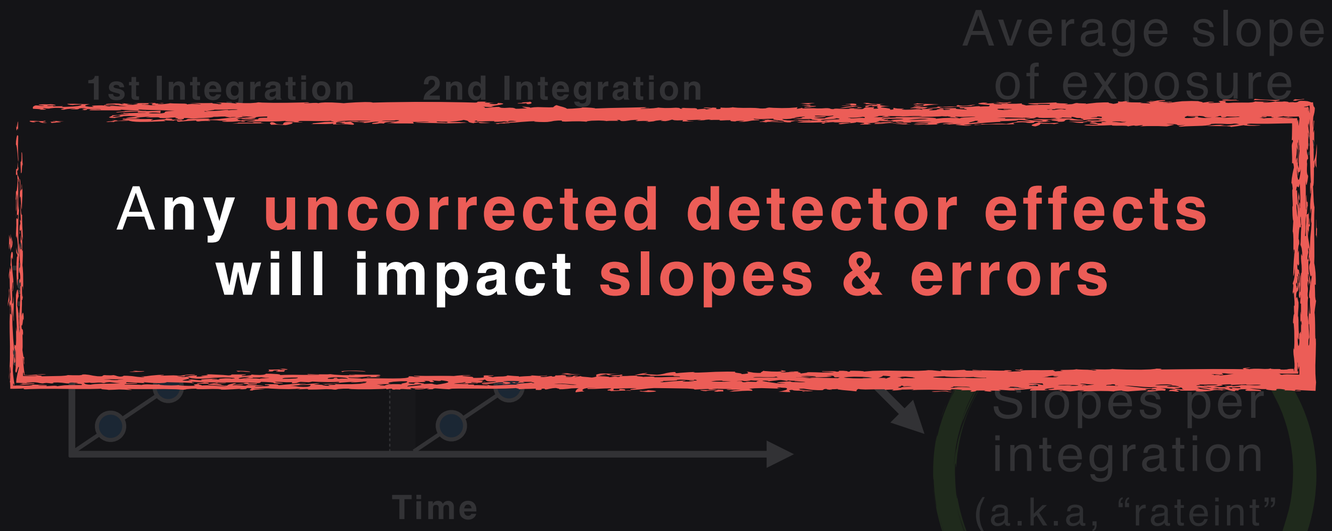
Stage 1 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

Near-IR			MIRI		
Step	**Non-TSO**	**TSO**	**Step**	**Non-TSO**	**TSO**
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc [1]			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence [2]	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

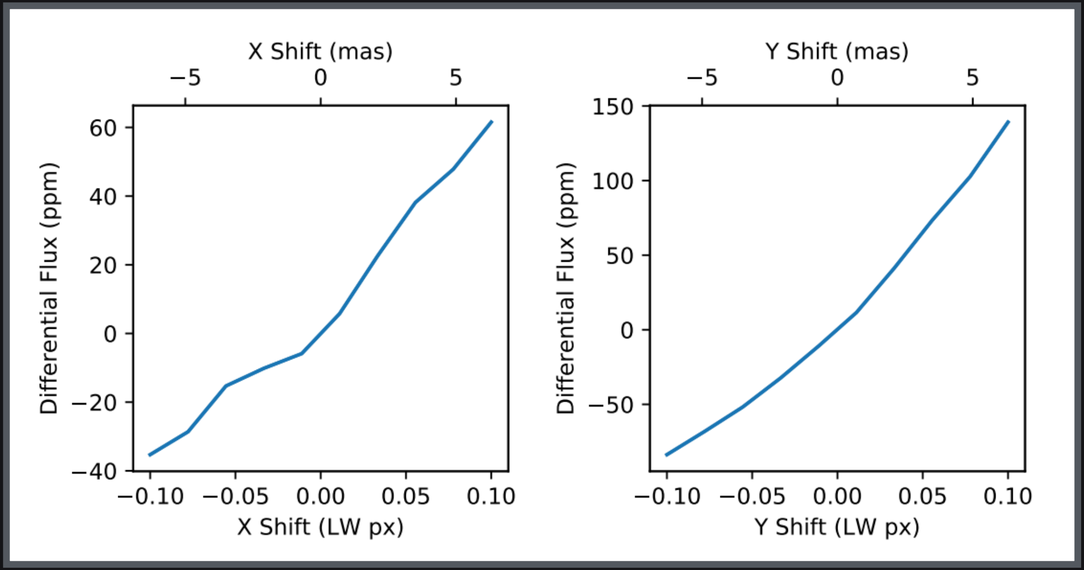
The **ramp_fitting** step obtains the slope on the up-the-ramp samples:



THE JWST DATA REDUCTION PIPELINE

Stage 2 steps, and what to be on the lookout for

The **flat_field** and **photom** step assume a static spectra in time.



Subpixel movement will likely cause flux variations (see Schlawin 2021, AJ, 161, 115)

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_spec2.html

Instrument/Mode	NIRSpec			MIRI			NIRISS		NIRCam	All
Step	FS	MOS	IFU	FS	SL	MRS	SOSS	WFSS	WFSS	TSO
assign_wcs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
background	✓	✓	✓	✓		✓	✓	✓	✓	
imprint		✓	✓							
msaflagopen		✓	✓							
extract_2d[1]	✓	✓						✓	✓	✓
srctype[1]	✓	✓	✓	✓	✓	✓	✓			✓
master_background		✓								
wavecorr	✓	✓								
flat_field[1]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
straylight						✓				
fringe						✓				
pathloss	✓	✓	✓				✓			
barshadow		✓								
photom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
resample_spec	✓	✓		✓						
cube_build			✓			✓				
extract_1d	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

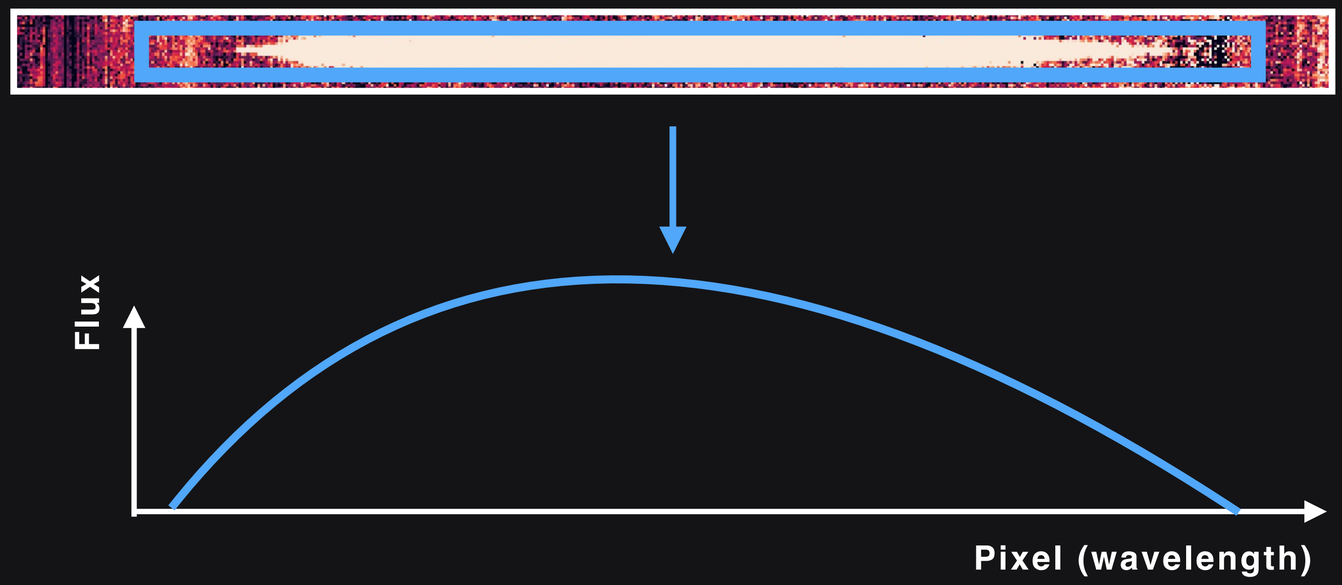
Stage 2 steps

THE JWST DATA REDUCTION PIPELINE

Stage 2 steps, and what to be on the lookout for

Current spectral extraction by **extract_1d** is “simple” extraction

e.g., JWST/NIRSpec:



jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_spec2.html

Instrument/Mode	NIRSpec			MIRI			NIRISS		NIRCam	All
Step	FS	MOS	IFU	FS	SL	MRS	SOSS	WFSS	WFSS	TSO
assign_wcs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
background	✓	✓	✓	✓		✓	✓	✓	✓	
imprint		✓	✓							
msaflagopen		✓	✓							
extract_2d[1]	✓	✓						✓	✓	✓
srctype[1]	✓	✓	✓	✓	✓	✓	✓			✓
master_background		✓								
wavecorr	✓	✓								
flat_field[1]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
straylight						✓				
fringe						✓				
pathloss	✓	✓	✓				✓			
barshadow		✓								
photom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
resample_spec	✓	✓		✓						
cube_build			✓			✓				
extract_1d	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

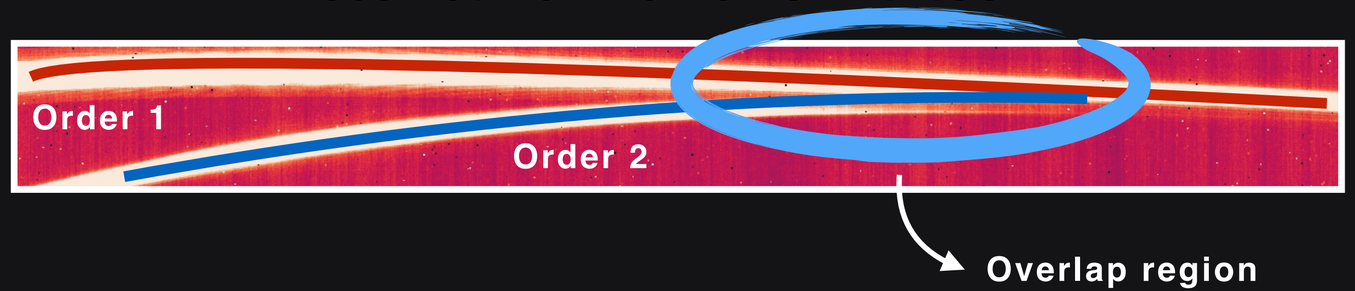
Stage 2 steps

THE JWST DATA REDUCTION PIPELINE

Stage 2 steps, and what to be on the lookout for

Current spectral extraction by **extract_1d** is “simple” extraction

Does not work for JWST/NIRISS:



jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_spec2.html

Instrument/Mode	NIRSpec			MIRI			NIRISS		NIRCam	All
Step	FS	MOS	IFU	FS	SL	MRS	SOSS	WFSS	WFSS	TSO
assign_wcs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
background	✓	✓	✓	✓		✓	✓	✓	✓	
imprint		✓	✓							
msaflagopen		✓	✓							
extract_2d[1]	✓	✓						✓	✓	✓
srctype[1]	✓	✓	✓	✓	✓	✓	✓			✓
master_background		✓								
wavecorr	✓	✓								
flat_field[1]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
straylight						✓				
fringe						✓				
pathloss	✓	✓	✓				✓			
barshadow		✓								
photom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
resample_spec	✓	✓		✓						
cube_build			✓			✓				
extract_1d	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Stage 2 steps

THE JWST DATA REDUCTION PIPELINE

Stage 2 steps, and what to be on the lookout for

Current spectral extraction by **extract_1d** is “simple” extraction

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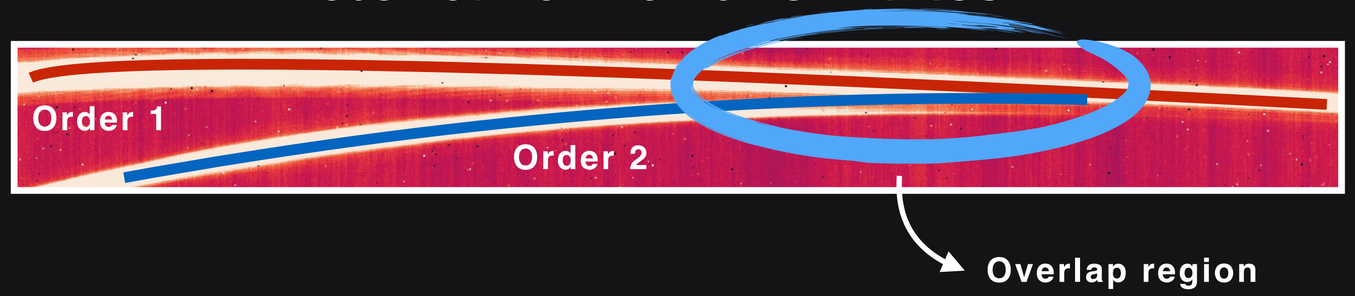

U. De Montreal folks (Darveau-Bernier, Albert, Lafreniere et al.,) working on implementing NIRISS/SOSS **algorithm** to **JWST pipeline!**

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_spec2.html

Instrument/Mode	NIRSpec			MIRI			NIRISS		NIRCam	All
Step	FS	MOS	IFU	FS	SL	MRS	SOSS	WFSS	WFSS	TSO
assign_wcs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
background	✓	✓	✓	✓		✓	✓	✓	✓	
imprint		✓	✓							
msaflagopen		✓	✓							
extract_2d[1]	✓	✓						✓	✓	✓
srctype[1]	✓	✓	✓	✓	✓	✓	✓			✓
master_background		✓								
wavecorr	✓	✓								
flat_field[1]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
straylight						✓				
fringe						✓				
pathloss	✓	✓	✓				✓			
barshadow		✓								
photom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
resample_spec	✓	✓		✓						
cube_build			✓			✓				
extract_1d	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Stage 2 steps

THE JWST DATA REDUCTION PIPELINE

Stage 3 steps, and what to be on the lookout for

jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_tso3.html

calwebb_tso3	Imaging	Spectroscopy
outlier_detection	✓	✓
tso_photometry	✓	
extract_1d		✓
white_light		✓

Stage 3 steps

Currently testing/validating **outlier_detection** and **white_light steps.**

THE JWST DATA REDUCTION PIPELINE

Stage 3 steps, and what to be on the lookout for

CURRENT PIPELINE IS THE "BASELINE" VERSION; ENHANCEMENTS ARE PLANNED

EXPECT UPDATES ESPECIALLY AFTER COMMISSIONING

AS A COMMUNITY, YOU ARE FUNDAMENTAL TO GET FEEDBACK!

SUMMARY

- **JWST DATA HAS ITS OWN PARTICULARITIES.** Instrumental systematics arising from detector electronics are something to be in the lookout for. **NIR detectors (NIRCam, NIRISS, NIRSpec) different from IR detectors (MIRI)**.

- **JWST DATA CAN BE CALIBRATED USING THE JWST PIPELINE.** Pipeline is **modular & written in Python**; has three **stages**, each of which has their individual steps. While still under active development, **learning to use it early on is a good strategy to understand (and provide feedback to) JWST data analysis**.

- **JWST DATA WILL BE RELEASED VIA MAST**. Data from all the pipeline **stages** (including uncalibrated data) will be released.

- **FOR THE FIRST DATA RELEASES, JWST PIPELINE PRODUCTS WILL LIKELY BE GOOD BUT NOT PERFECT ANSWERS**. The JWST Pipeline (and all others) will evolve in time; expect this evolution to be fast at the beginning, where we will learn more of the on-sky performance of the observatory.