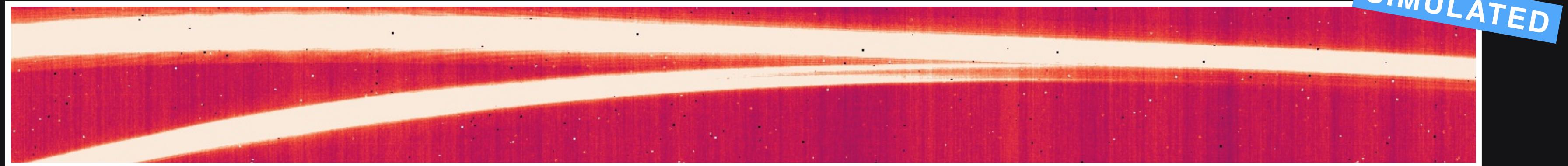


JWST DATA: WHAT DOES IT LOOK LIKE? HOW TO CALIBRATE IT & WHAT TO EXPECT

NÉSTOR ESPINOZA I  STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

JWST DATA: WHAT DOES IT LOOK LIKE?

NIRISS



NIRCAM

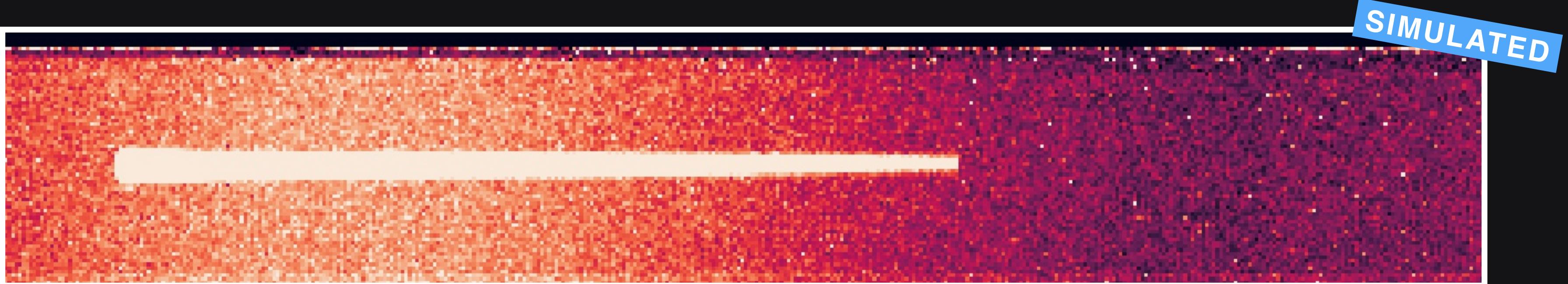


SPECTROSCOPIC
JWST DATA: WHAT DOES IT LOOK LIKE?

NIRSPEC



MIRI



NIRISS

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**.

MIRI

IMPORTANT RESOURCES TO KEEP IN MIND

NIRCAM

jwst-docs.stsci.edu

The screenshot shows the homepage of the JDox website. At the top is a navigation bar with a hexagonal logo, 'Home', and 'Quick Links'. Below it is a sidebar with sections for 'Proposing Opportunities' (including links to Cycle 1 General Observer proposals and Director's Discretionary Early Release Science Call for Proposals), 'Cycle 1 Guaranteed Time Observations Call for Proposals', 'General Science Policies', 'James Webb Space Telescope Science Policies Group and Review Information', and 'James Webb Space Telescope Grants Preparation'. Another sidebar on the left lists 'Proposal Preparation' topics like 'Getting Started with JWST Proposing' and 'Understanding Exposure Times'. The main content area features a heading 'JWST User Documentation Home' with a small telescope icon, a note about Cycle 1 GO proposals closing on November 24, 2020, and a table comparing 'Proposing tools' (APT and ETC) across columns for 'Current version' and 'Release date'.

jwsthlp.stsci.edu

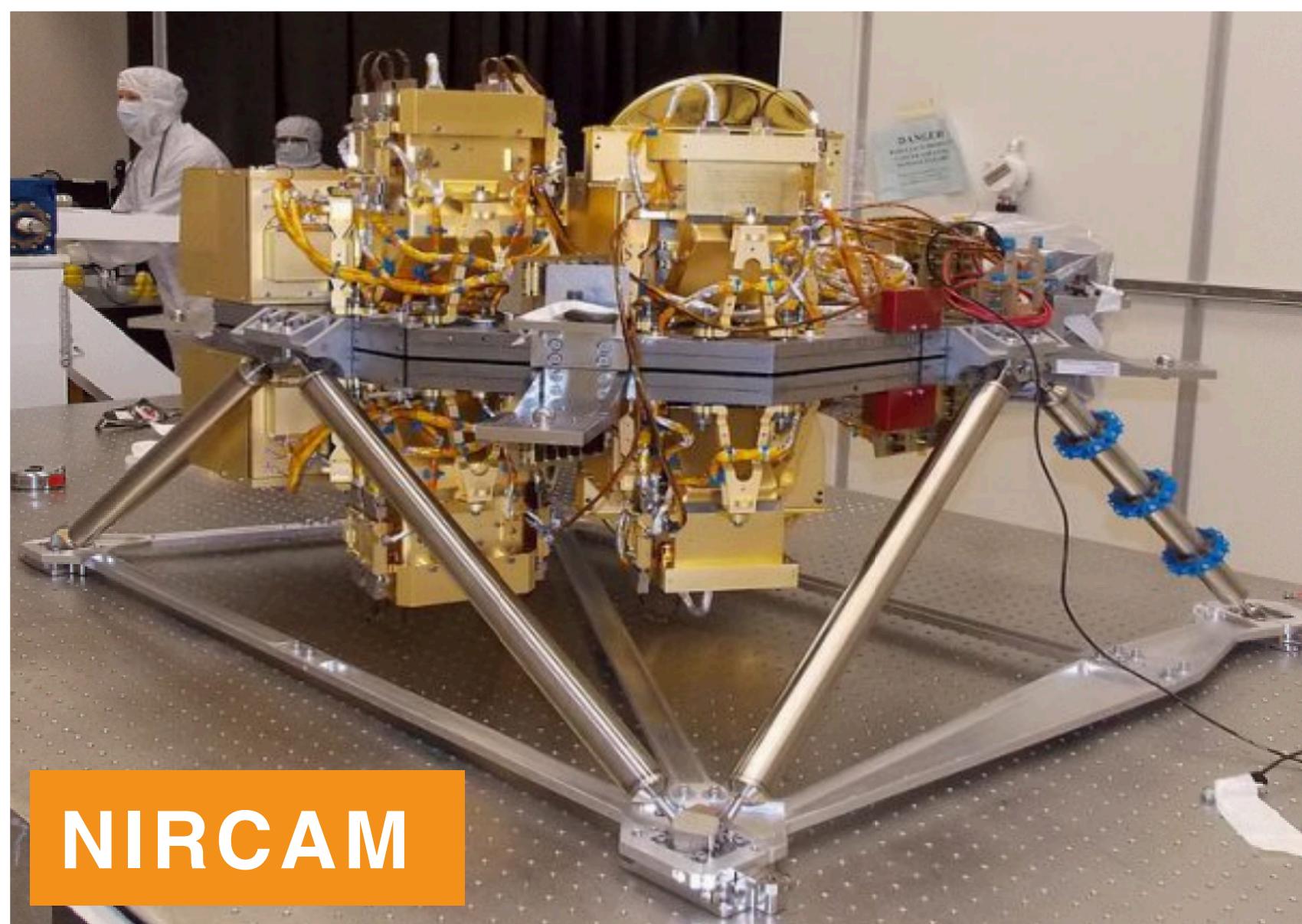
The screenshot shows the JWST Help Desk homepage. It features a large yellow background with a network-like pattern of lines. A central callout box asks 'How can we help?' and includes a search bar labeled 'Search JWST Knowledge Base and Documentation System (JDox)'. Below this are two main buttons: 'Knowledge Base' with a book icon and 'Get Help' with a person icon. The top navigation bar includes links for 'Knowledge', 'Service Portals', 'My Open Tickets (1)', 'My Open Requests (15)', and a user profile for 'Nestor Espinoza'.

MIRI

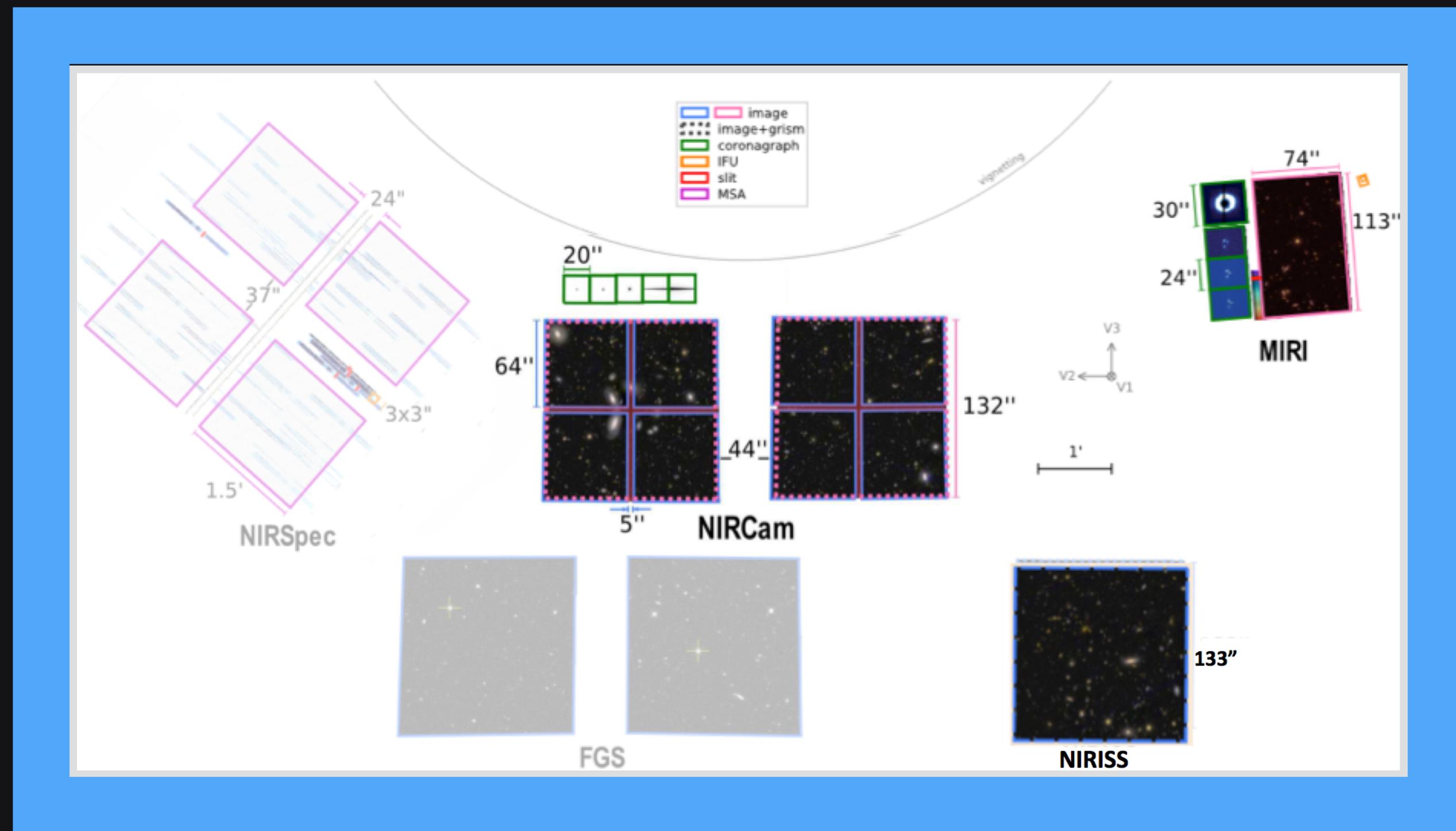
PART 1

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



0.6 1.0 2.0 3.0 4.0 5.0

NIRISS

SOSS

F322W2

NIRCAM

F444W

*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

G440M/H

G235/H

PRISM

0.6

1.0

WHAT YOU'LL LEARN HERE

(E.G. SIMILAR DETECTORS)

5.0

SOSS

F322W2

F444W

NIRISS

NIRCAM

MRS1

MRS2

MRS3

MRS4

IR INSTRUMENTS
(Si:As IBC DETECTORS)

5.0

7.7

11.0

19.4

29.0

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**

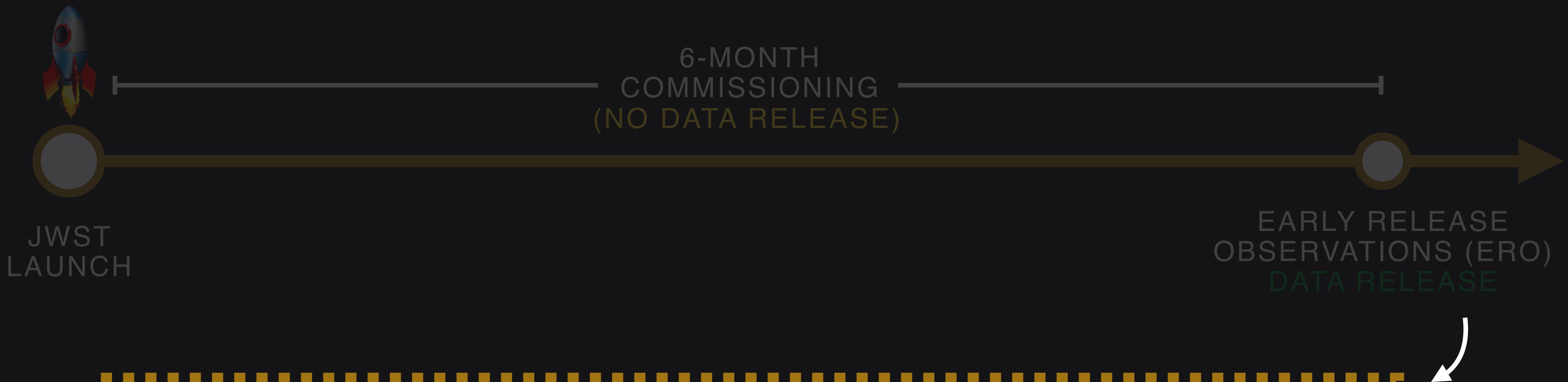
(AT LEAST AT THE BEGINNING)



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

The screenshot shows the 'Installation' section of the documentation. It includes a sidebar with links to various sections like Introduction, Reference Files, CRDS, and Error Propagation. The main content area has a header 'Index | Module Index' and a sub-header 'Installation'. It explains how to install the package via pip or conda, provides details on conda installation, and lists a 3-step process for creating a conda environment. It also shows a bash-compatible shell command for creating a conda environment.

Index | Module Index

Installation

Stable releases of the `jwst` package are registered at [PyPI](#). The latest released version can be installed into a fresh virtualenv or conda environment using pip:

```
pip install jwst
```

Installation details (via conda) ¶

The `jwst` package should be installed into a virtualenv or conda environment via `pip`. We recommend that for each installation you start by creating a fresh environment that only has Python installed and then install the `jwst` package into that bare environment.

If using conda environments, first make sure you have a recent version of Anaconda or Miniconda installed.

Installation is generally a 3-step process:

- Create a conda environment
- Activate that environment
- Install the `jwst` package into that environment

In a bash-compatible shell:

```
conda create -n <env_name> python  
conda activate <env_name>  
pip install jwst
```

For more detailed instructions and alternate installation methods see the [GitHub README](#)

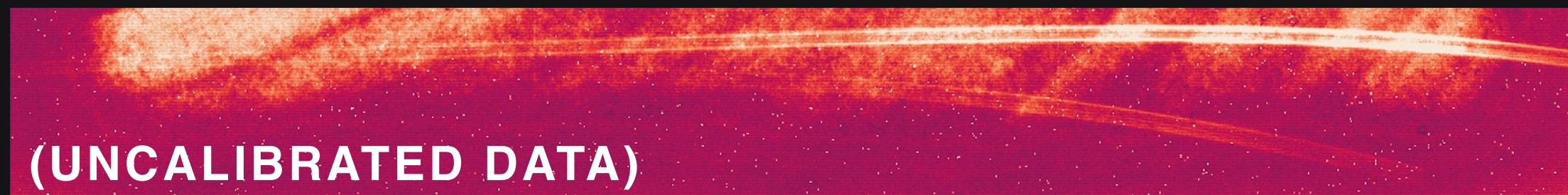
- Really, a JWST pipeline.
- Coded in **Python**. Modular. Open source.
- Algorithms tailored to particular instruments and modes.
- Has direct input from **JWST** instrument teams.
- Currently under active development at STScl.

*TSO: Time-Series Observation

THE JWST DATA REDUCTION PIPELINE

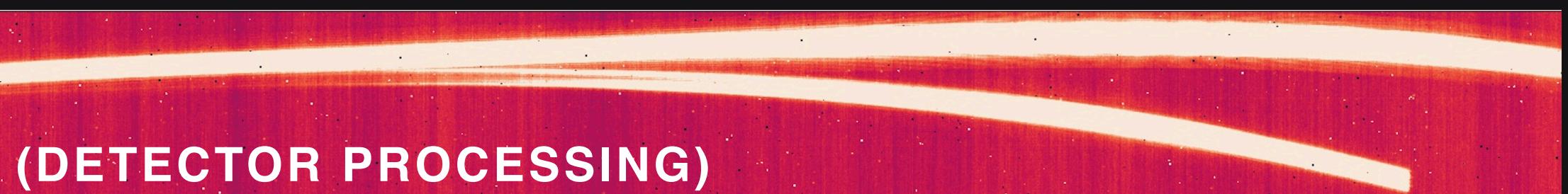
The calibration pipeline is divided into **Stages**. For *TSOs:

STAGE 0:

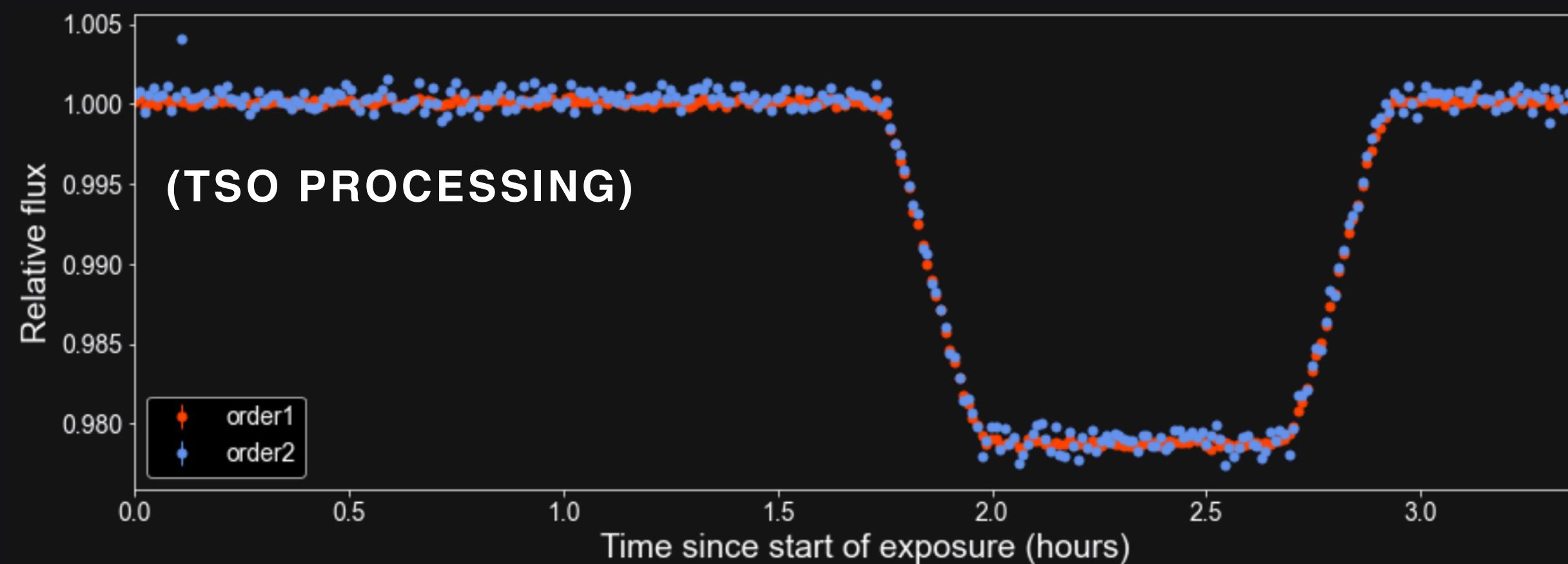


Simulated uncalibrated (*.uncal.fits) NIRISS/SOSS data

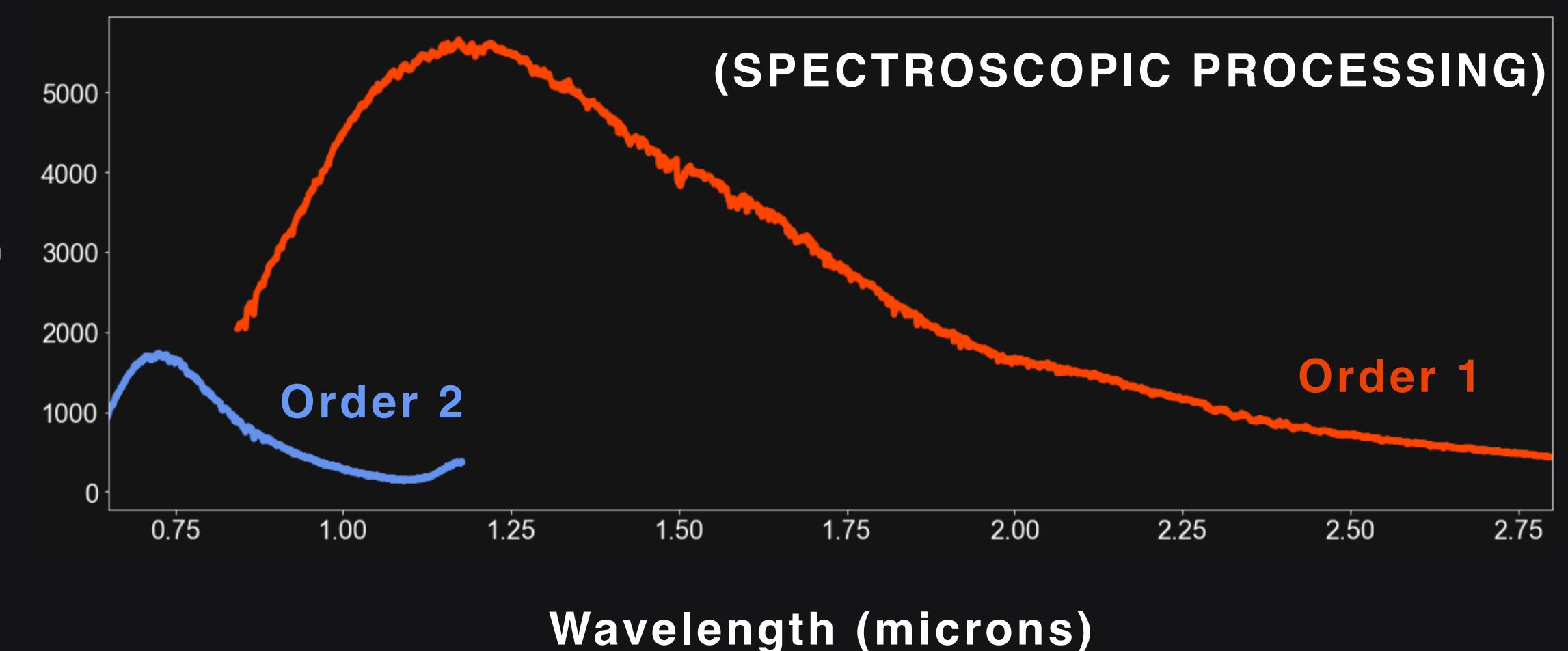
AFTER STAGE 1:



AFTER STAGE 3:



AFTER STAGE 2:



*TSO: Time-Series Observation

THE JWST DATA REDUCTION PIPELINE

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

STAGE 0:

AFTER STAGE 1:

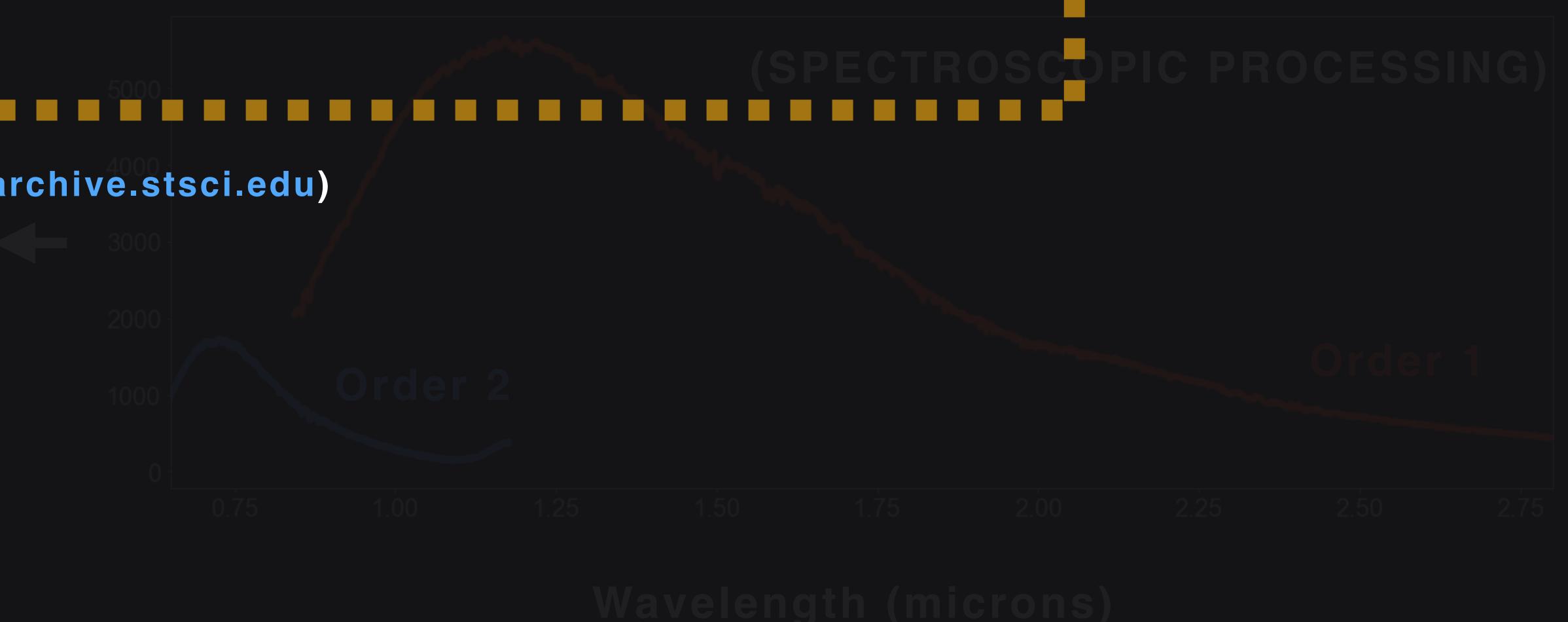
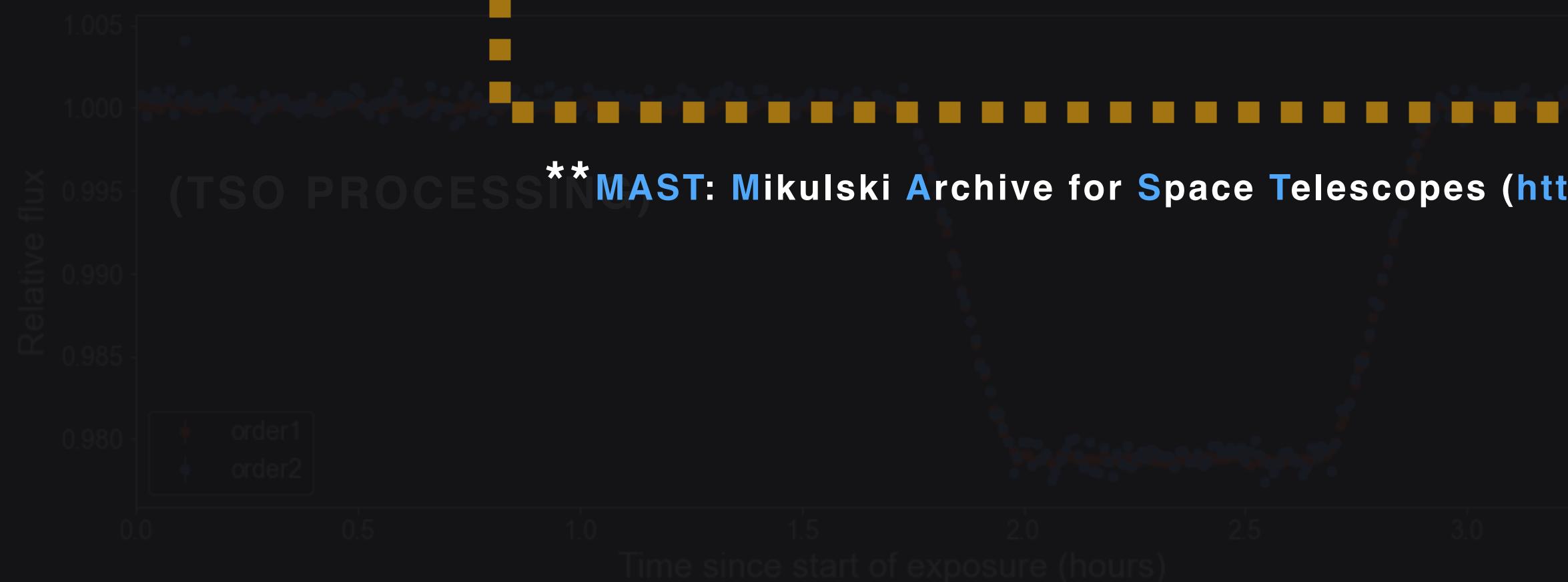
(UNCALIBRATED DATA)

(DETECTOR PROCESSING)

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

WHEN JWST DATA GETS DELIVERED TO YOU (VIA MAST**),
PRODUCTS AT ALL STAGES

AFTER STAGE 3: WILL BE AVAILABLE!



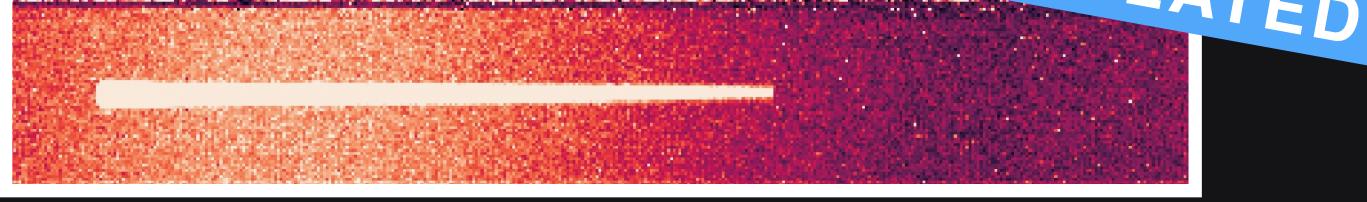
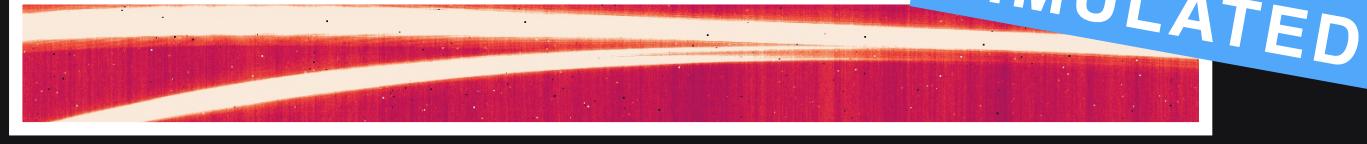
**MAST: Mikulski Archive for Space Telescopes (<https://archive.stsci.edu>)

THE SIMULATED ERS DATASETS

[HTTPS://ERS-TRANSIT.GITHUB.IO/PRE-LAUNCH-HACKATHON.HTML#DATA-AND-COMPUTING](https://ers-transit.github.io/pre-launch-hackathon.html#data-and-computing)

All Files > JWST ERS 1366 (Batalha) > Data Simulation Working Group		
Name	Updated	Size
 NIRCam	Jun 17, 2021 by Thomas Beatty	108 Files
 mini-NIRCam	Jun 17, 2021 by Zach Berta-Thompson	4 Files
 NIRISS	Jun 14, 2021 by Nestor Espinoza	7 Files
 MIRI	May 14, 2021 by Sarah Kendrew	47 Files
 NIRSpec	May 14, 2021 by Aarynn Carter	26 Files
 MeetingNotes-2021-03-03.pdf	Apr 6, 2021 by Kevin Stevenson	615.1 KB
 MeetingNotes-2021-02-03.pdf	Apr 6, 2021 by Kevin Stevenson	1.5 MB
 MeetingNotes-2021-02-17.pdf	Apr 6, 2021 by Kevin Stevenson	1.5 MB

THE SIMULATED ERS DATASETS

	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	✓	✓	✗	✗

(Nintegrations, Ngroups, Pixel, Pixel)

(Nintegrations, Pixel, Pixel)

(Nintegrations, Pixel)

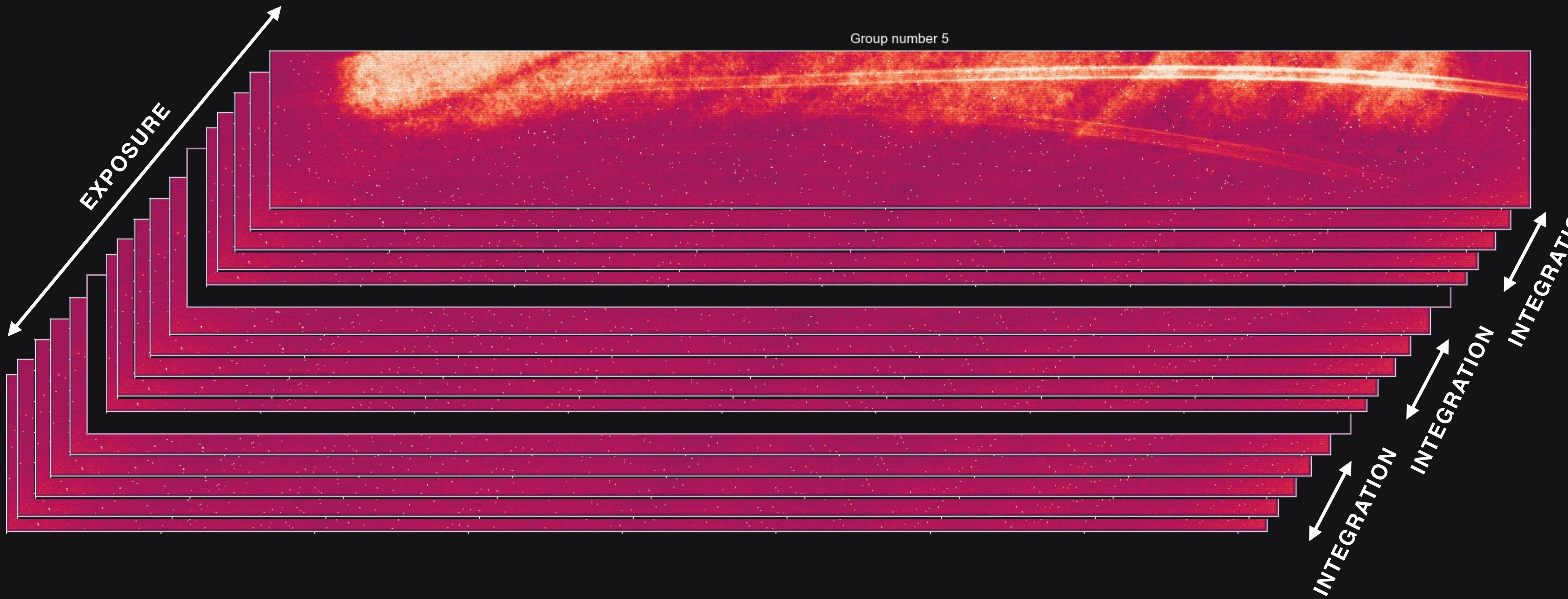
PART 3

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)

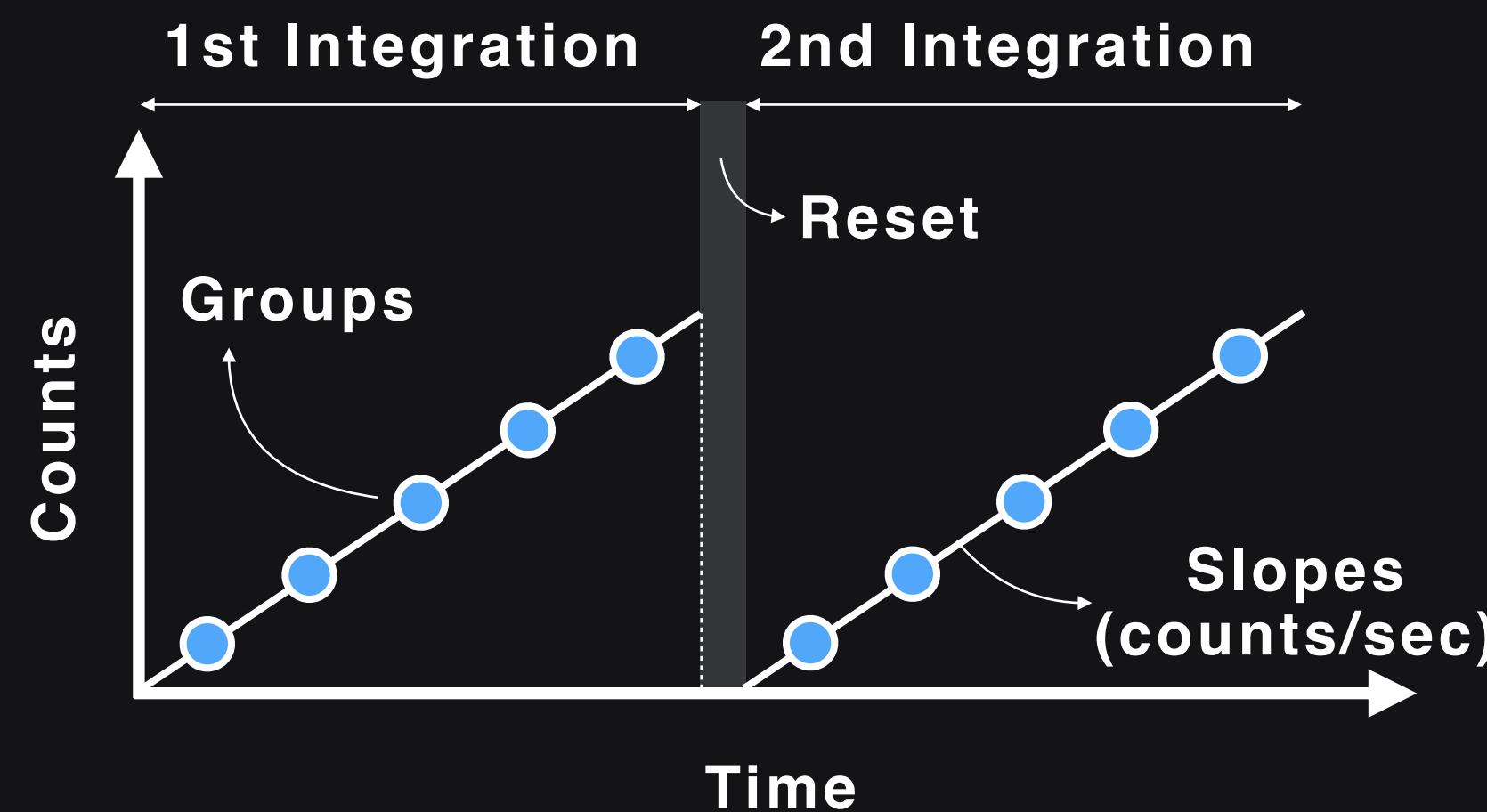


JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

A normal pixel

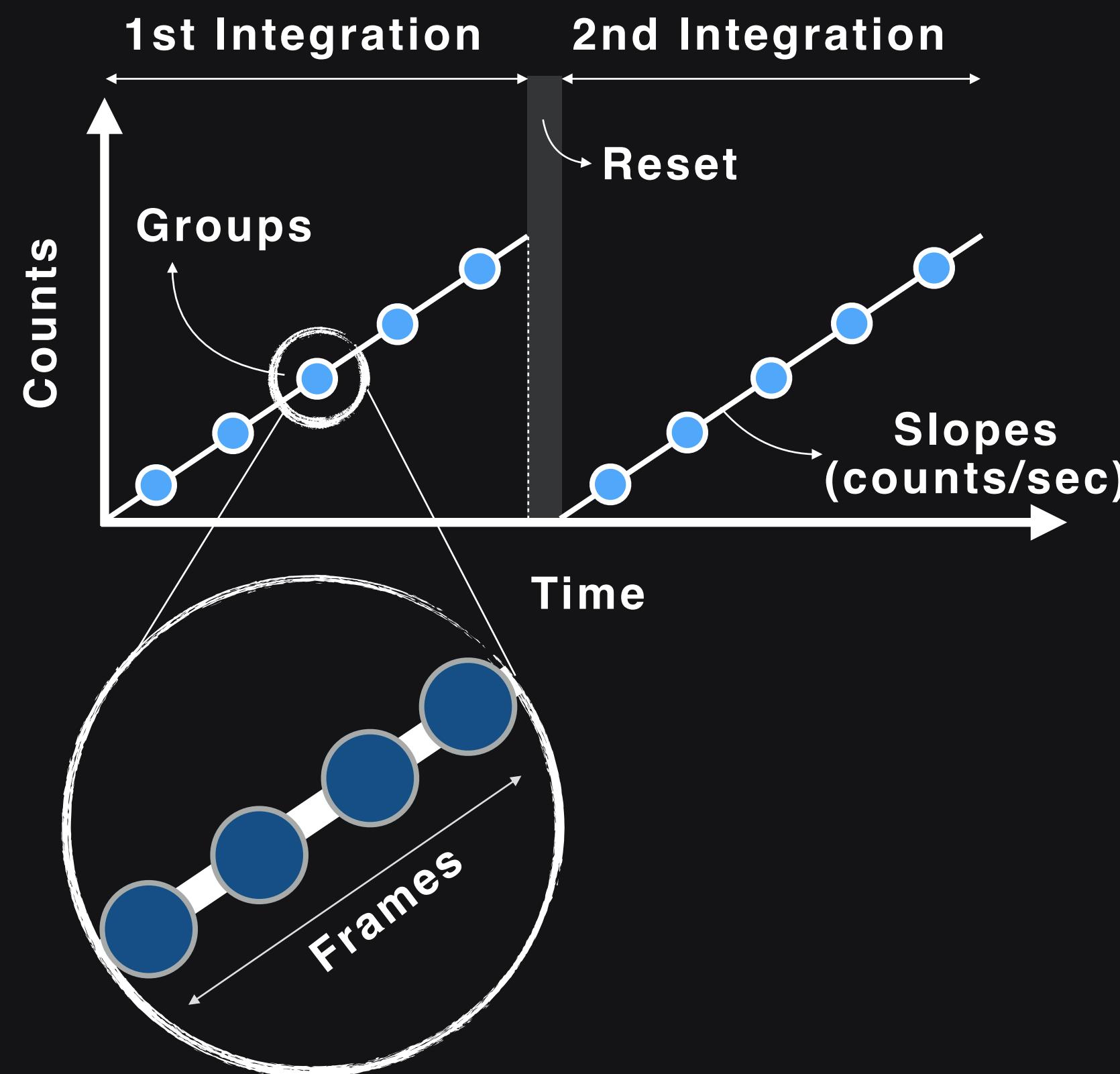


JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

A normal pixel

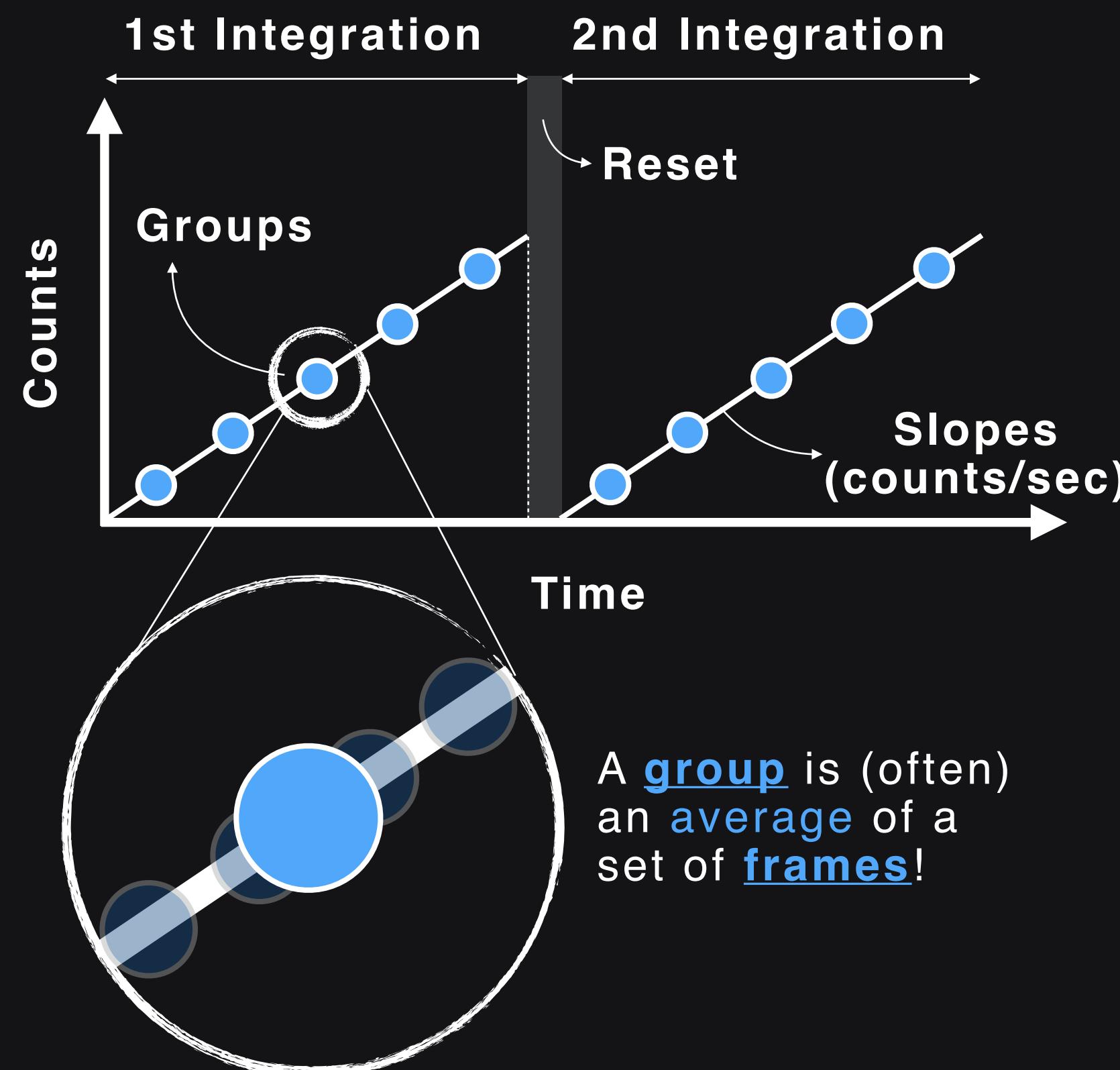


JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

A normal pixel

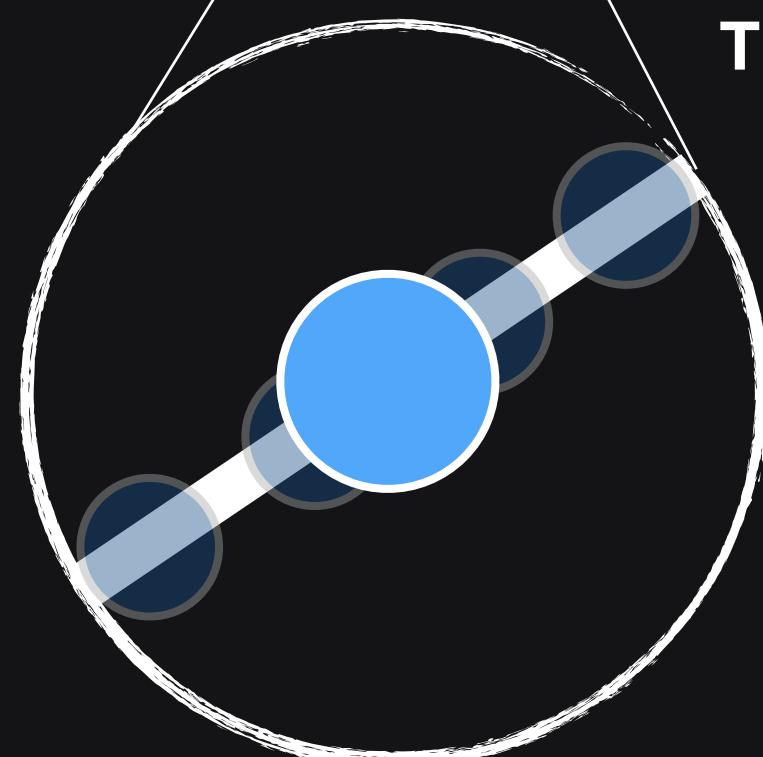
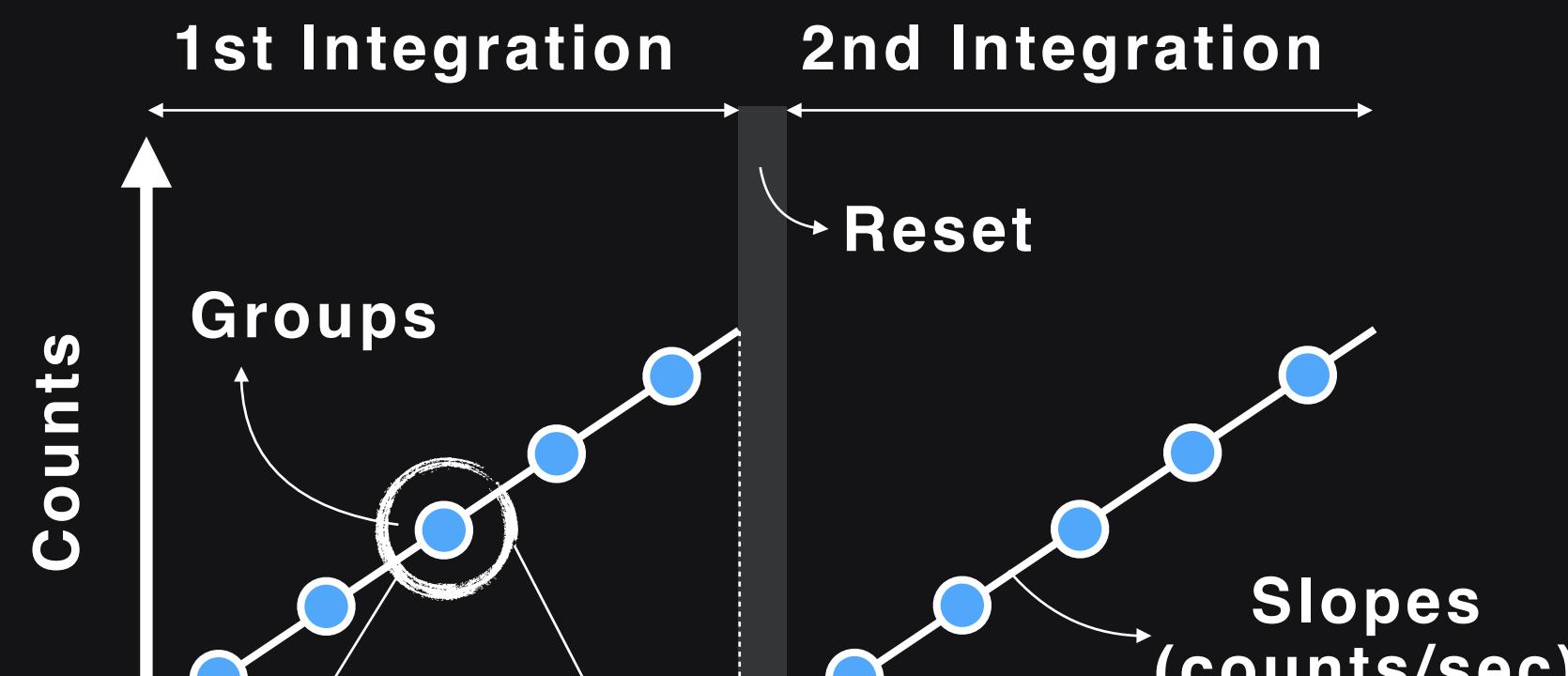


JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

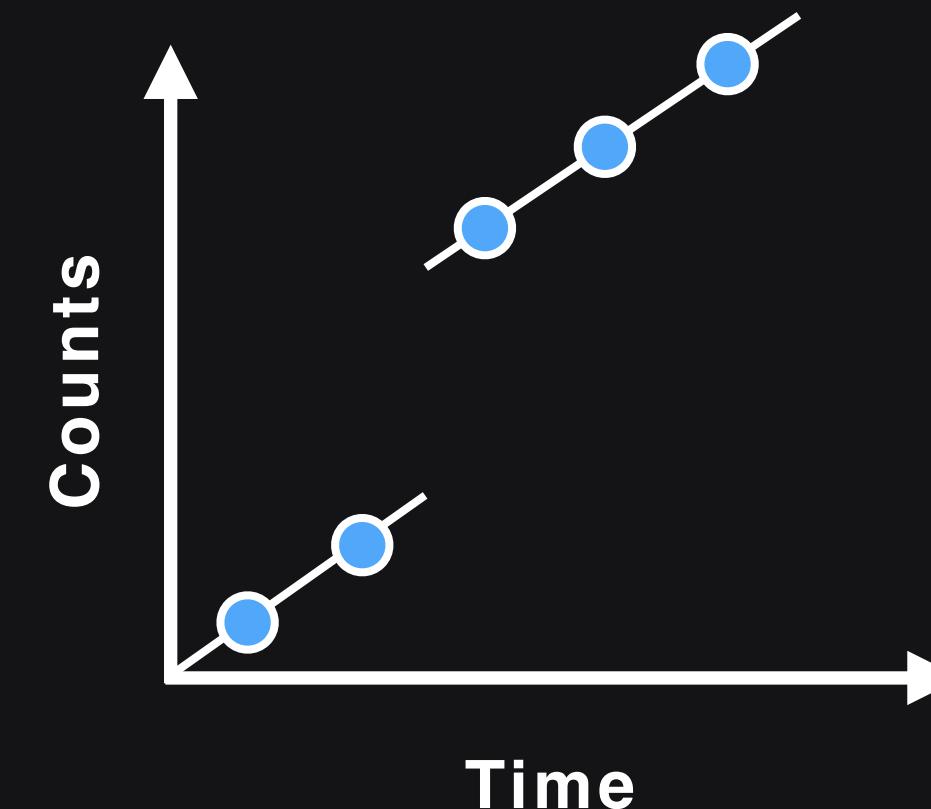
(a.k.a. MULTIACCUM)

A normal pixel



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

Pixel hit by CR



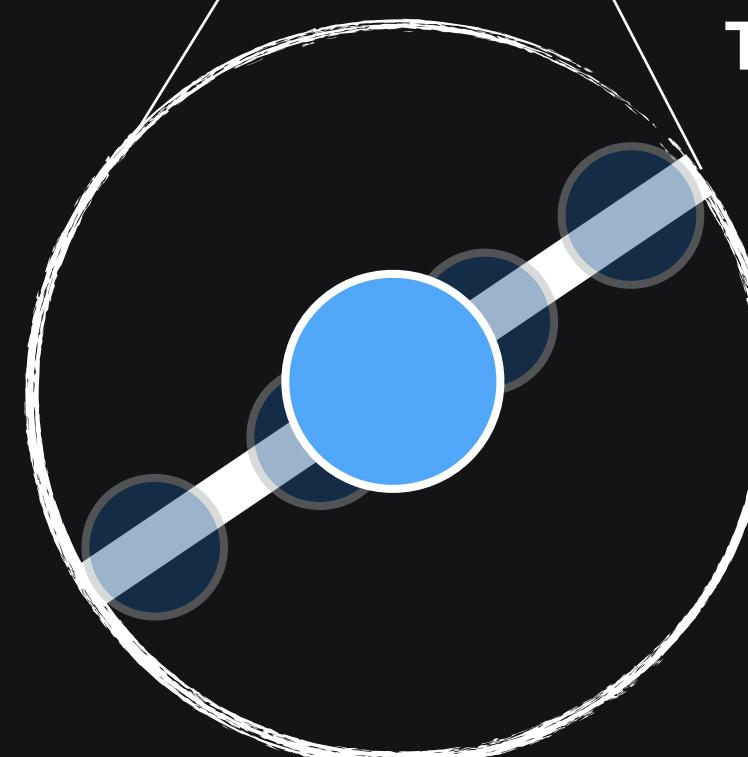
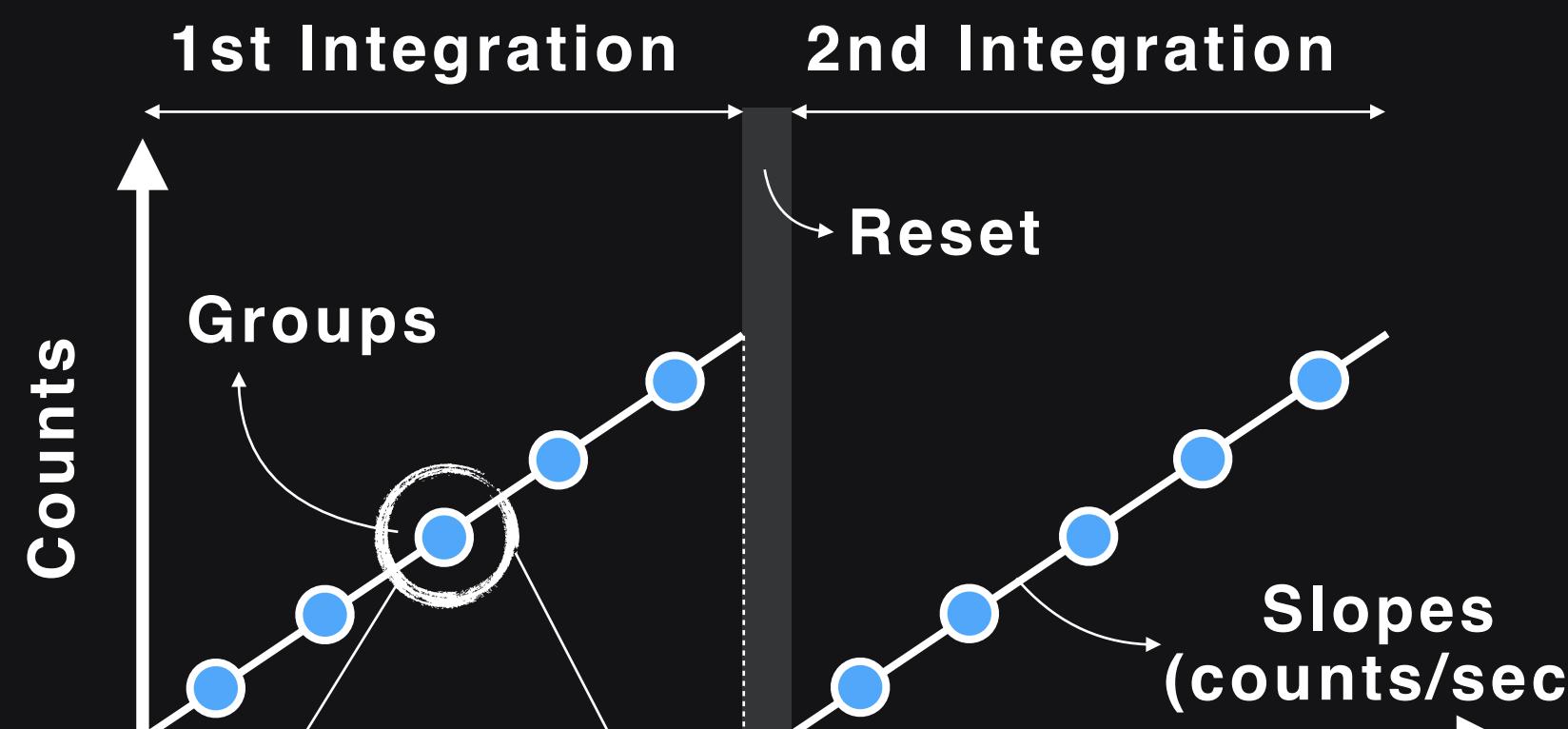
Cosmic rays can be
modeled as “jumps” in an
up-the-ramp sample.

JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

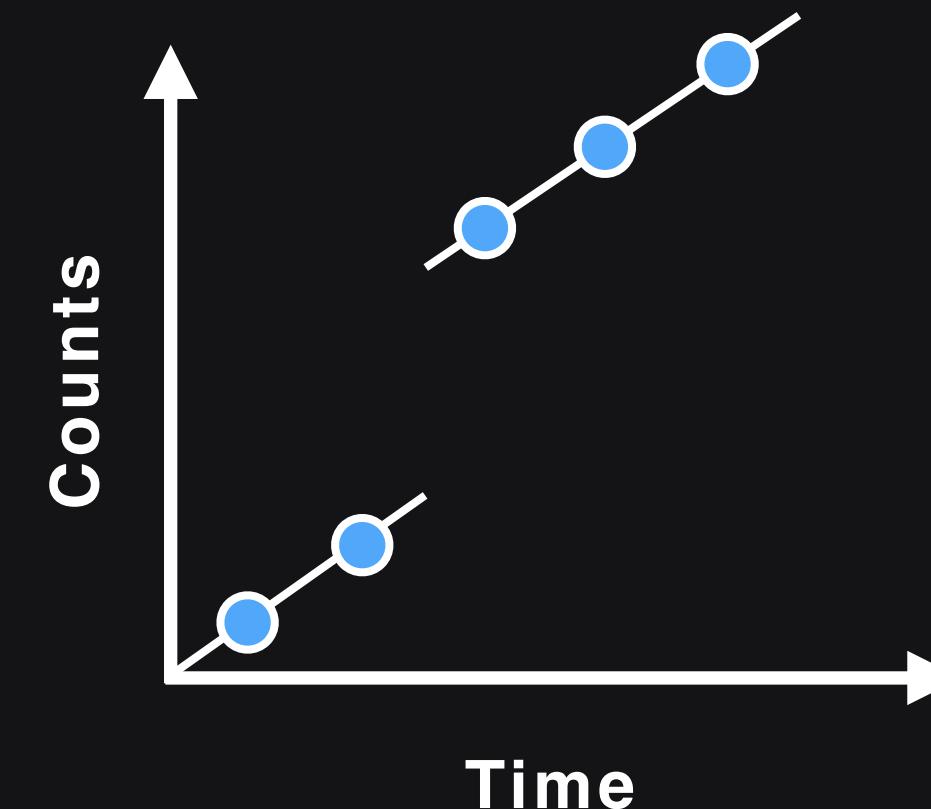
(a.k.a. MULTIACCUM)

A normal pixel



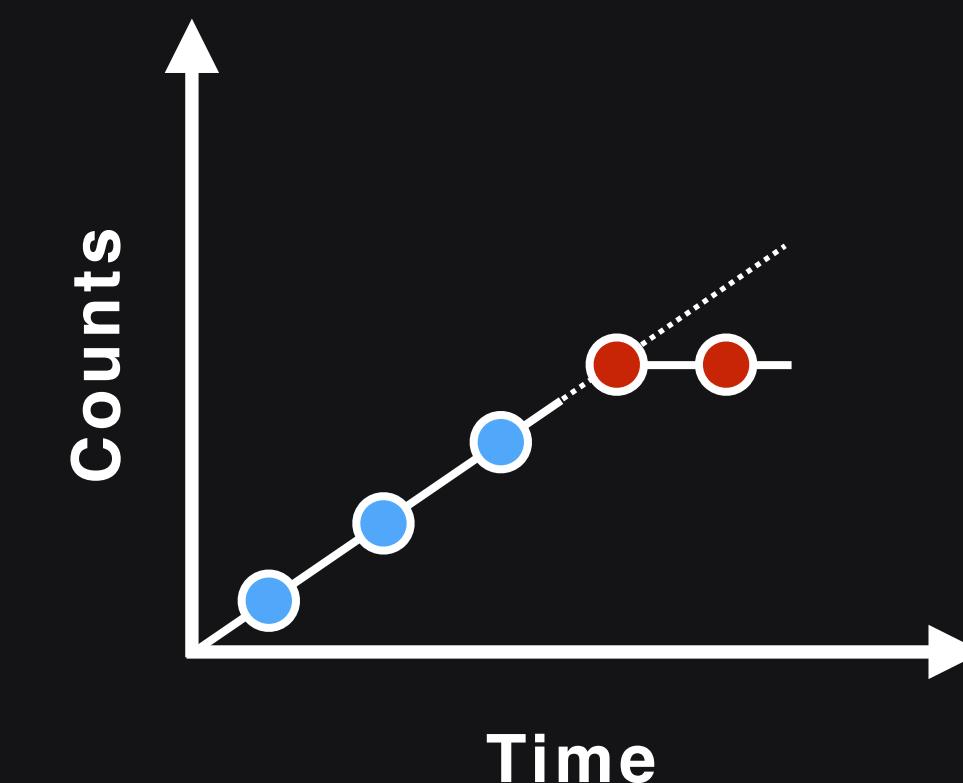
A **group** is (often)
an average of a
set of **frames**!

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
- ▶ nirss
- ▶ 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 map 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 map to add FILTER as one of the selection criteria, and to return NA for a reference file for any pupil values other than GRISM and GRISM, 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

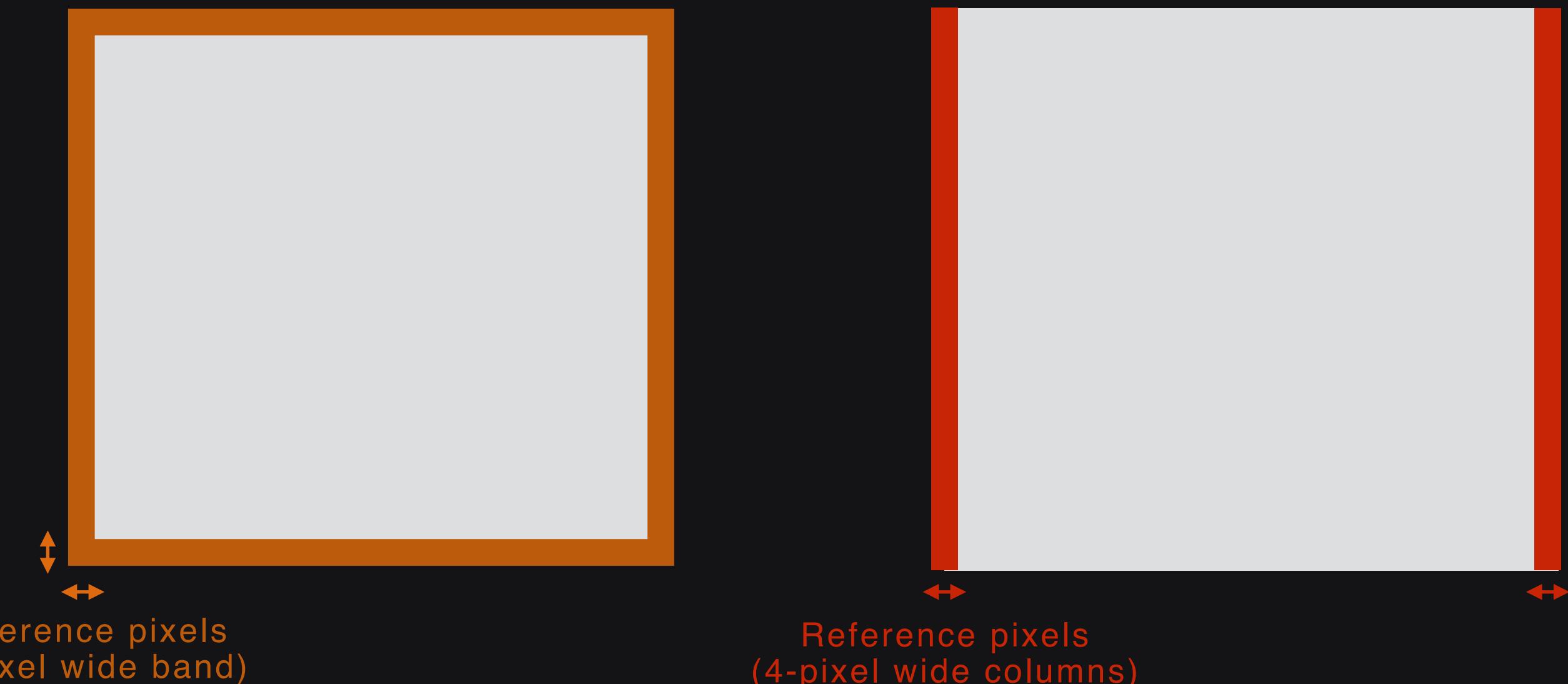
The **refpix** step aims to correct detector variations using **reference pixels**:

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

NIR detectors

(i.e., MIRI)

IR detectors



THE JWST DATA REDUCTION PIPELINE

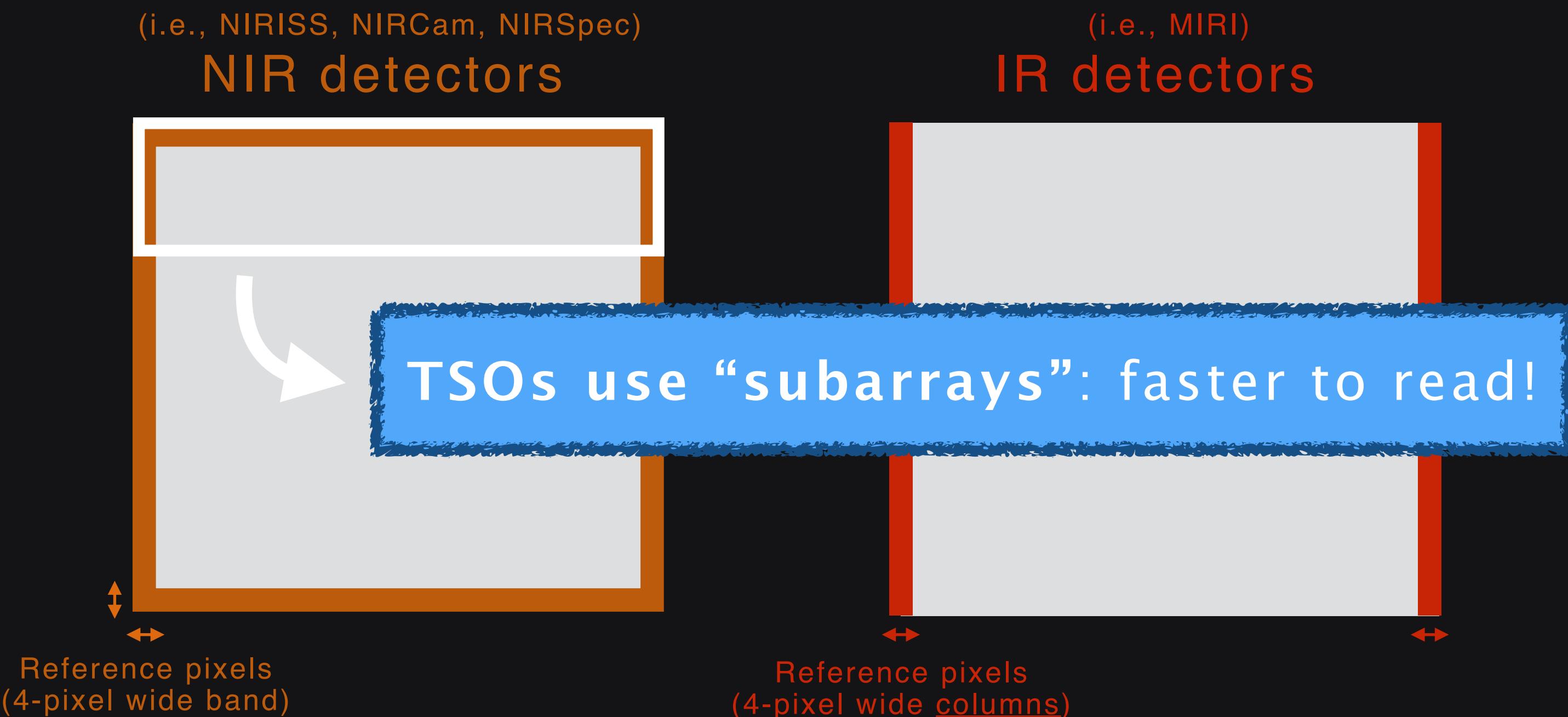
Stage 1 steps, and what to be on the lookout for

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**:



THE JWST DATA REDUCTION PIPELINE

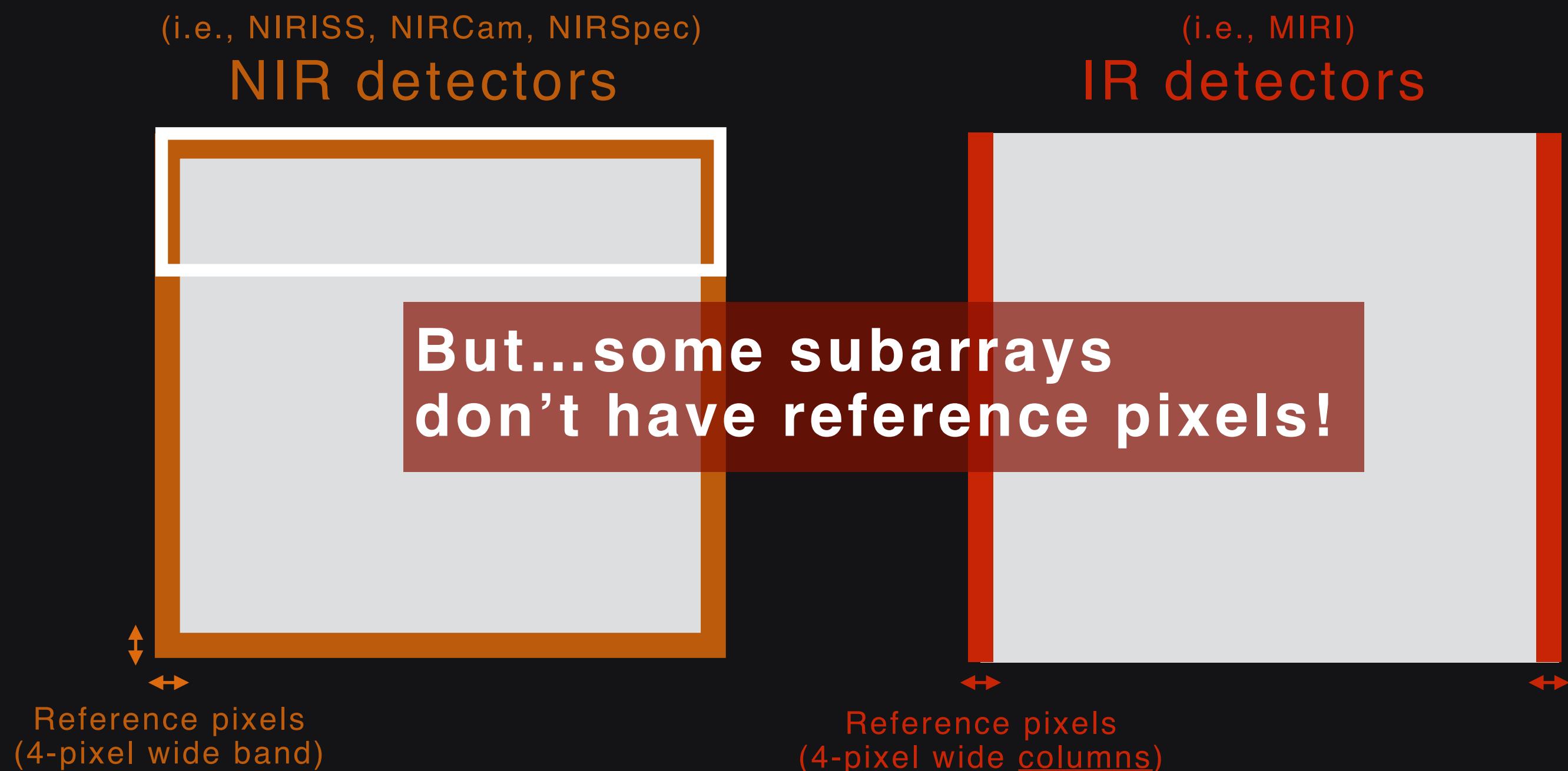
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Near-IR		MIRI			
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saturation	✓	✓	saturation	✓	✓
ipc ¹			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence ²	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			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
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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)

SLITLESSPRISM
(LRS subarray) has
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

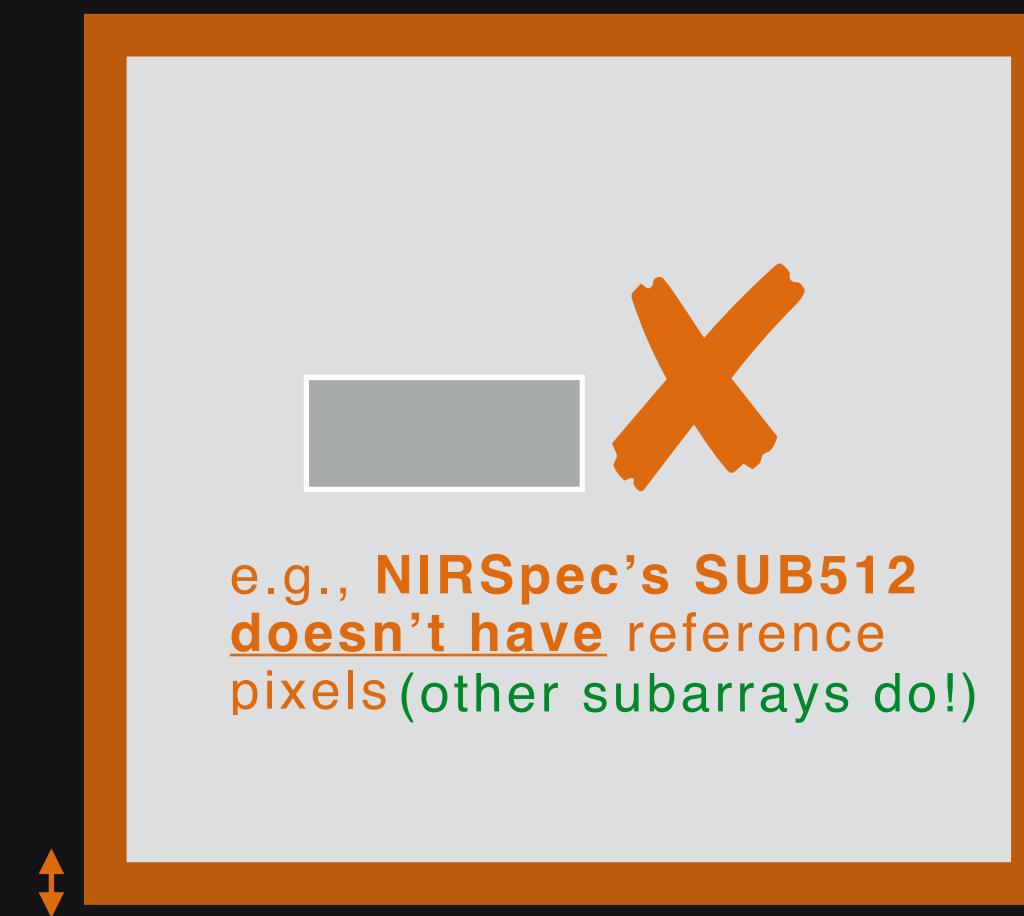
Near-IR		MIRI			
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc ¹			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence ²	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓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

Stage 1 steps

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

(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

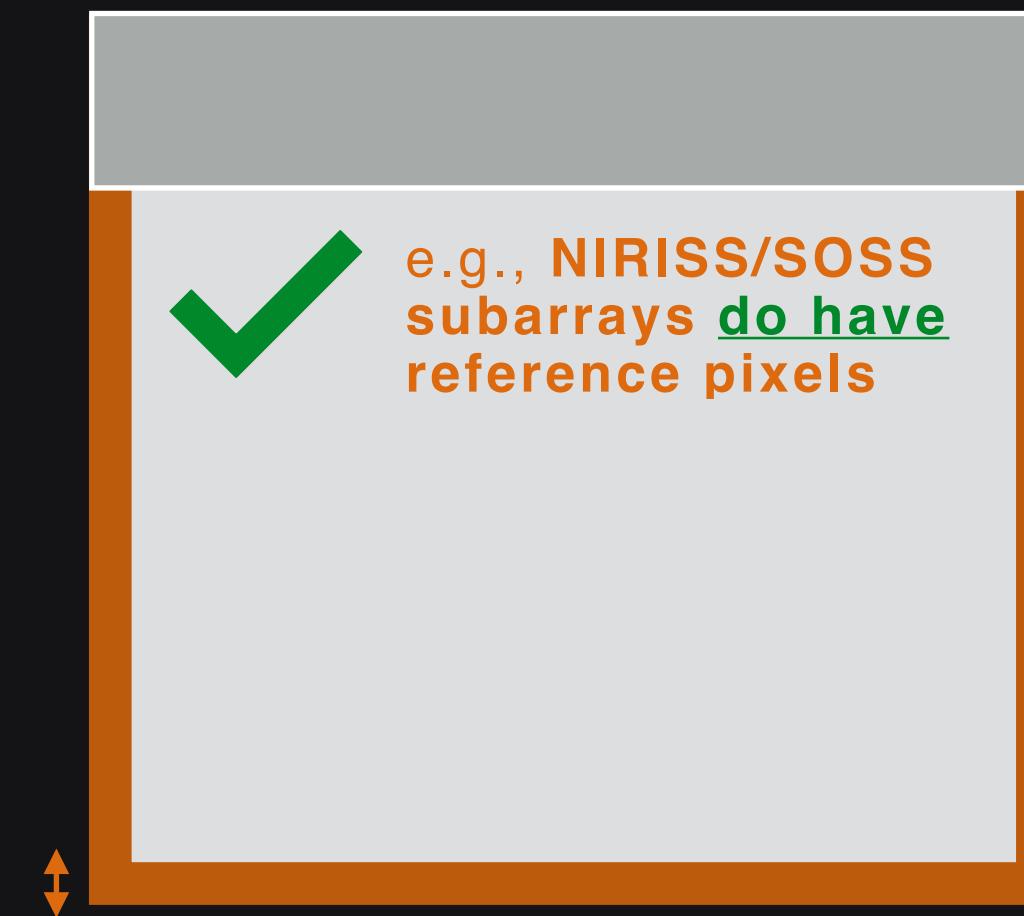
Near-IR		MIRI			
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc ¹			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence ²	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
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



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

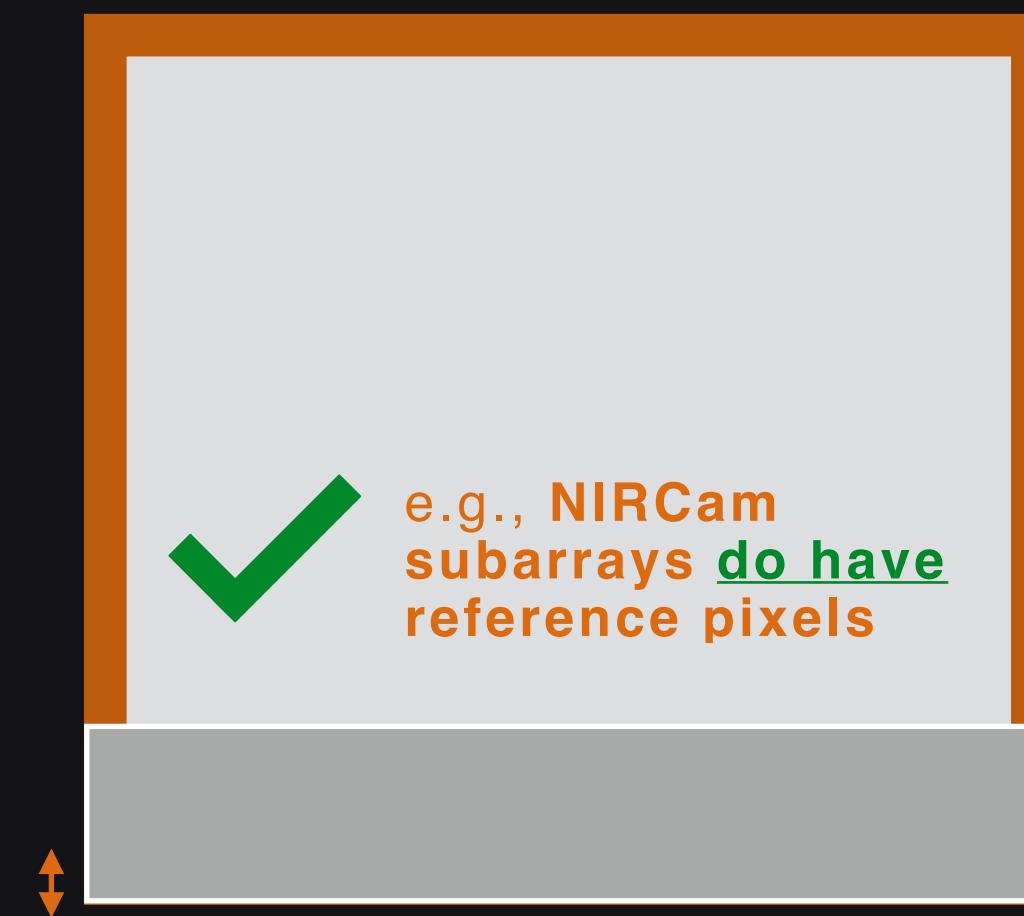
Near-IR		MIRI			
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc ¹			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence ²	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
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



Reference pixels
(4-pixel wide band)

(i.e., MIRI)

IR detectors



Reference pixels
(4-pixel wide columns)

THE JWST DATA REDUCTION PIPELINE

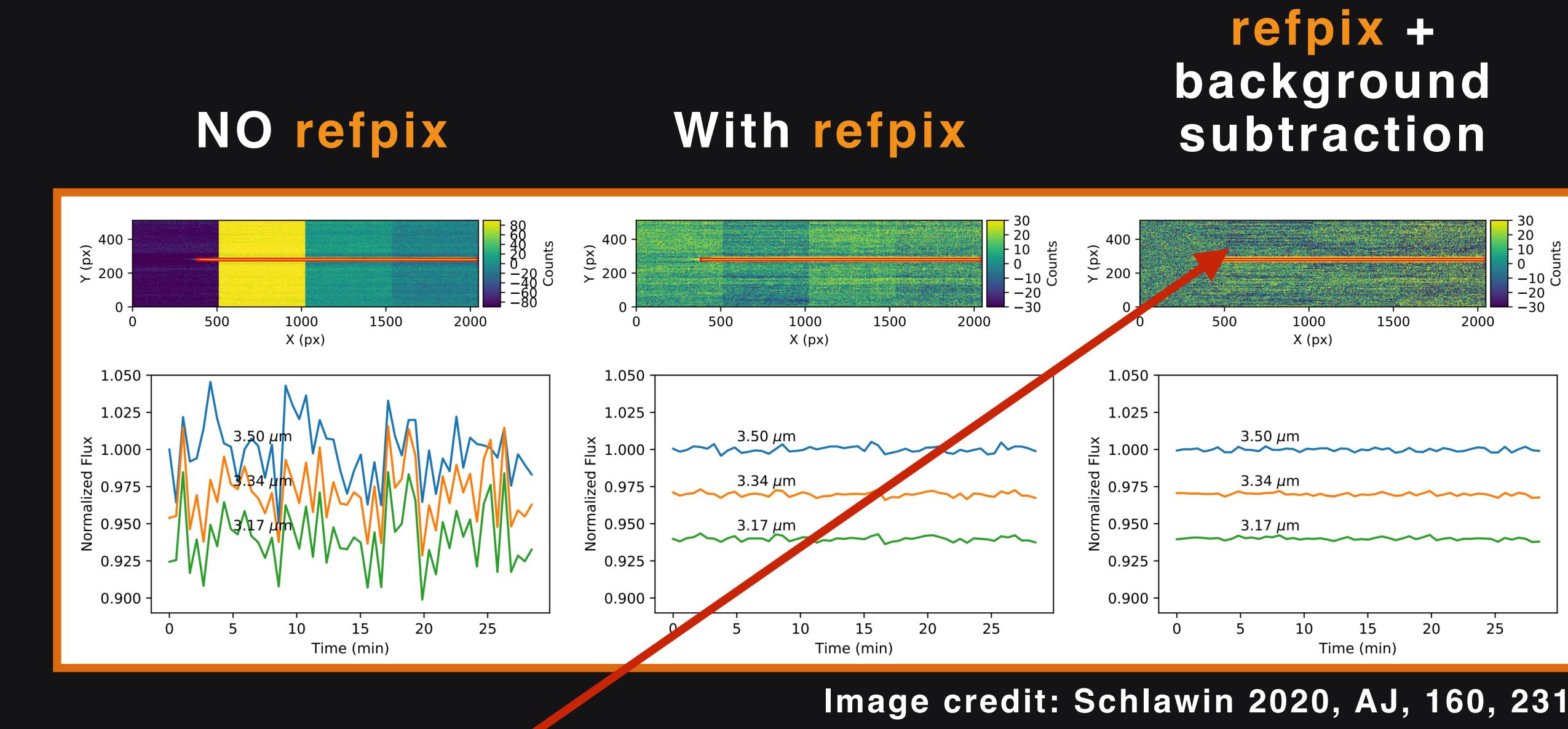
Stage 1 steps, and what to be on the lookout for

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**:



“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

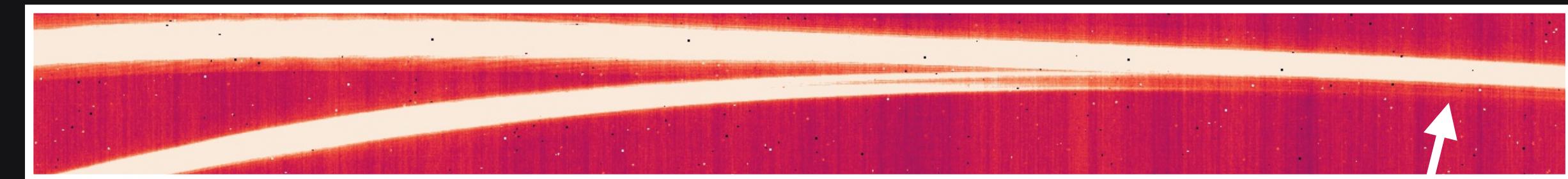
jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

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

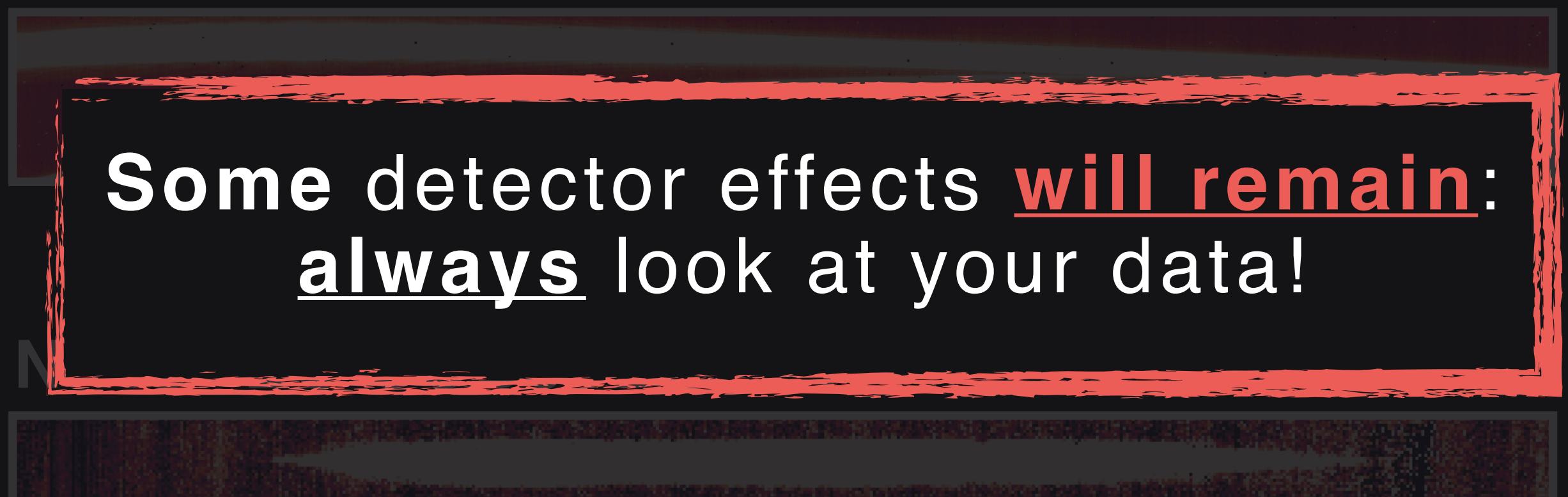
jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

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**:

NIRISS AFTER STAGE 1



THE JWST DATA REDUCTION PIPELINE

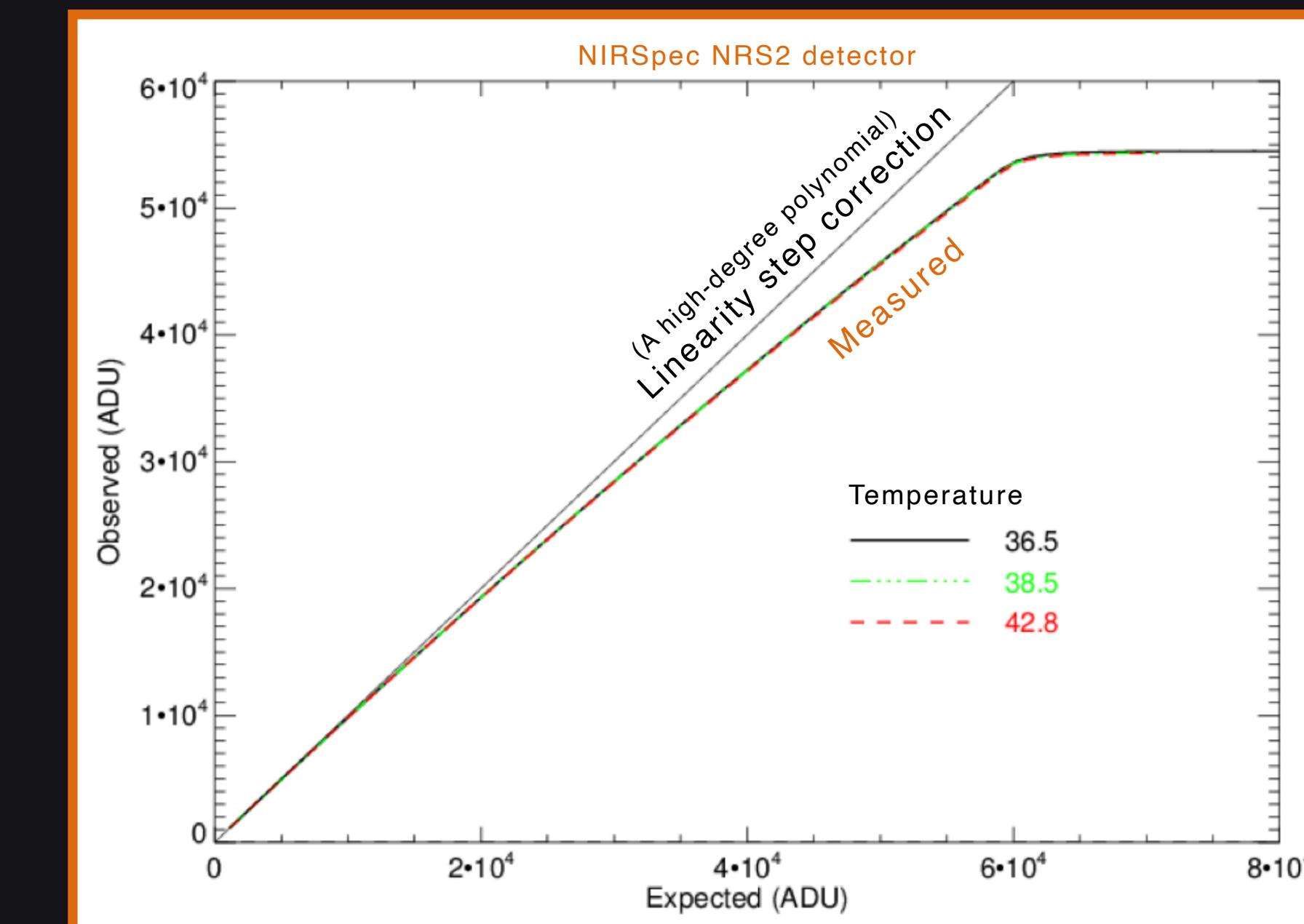
Stage 1 steps, and what to be on the lookout for

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

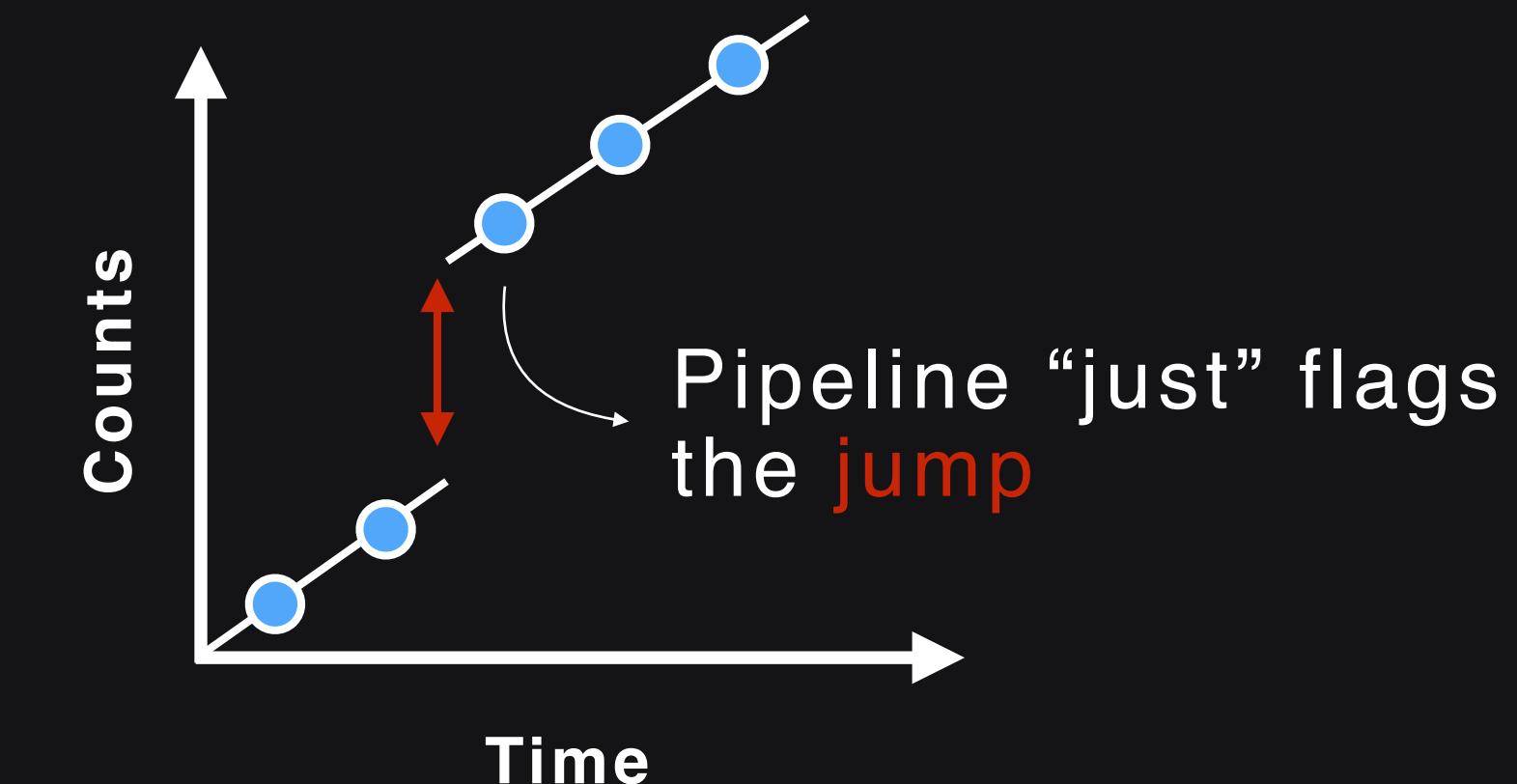
jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html

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	✓	✓

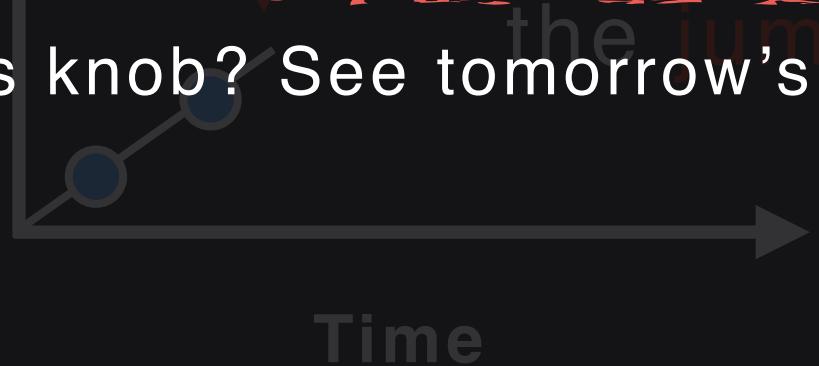
Stage 1 steps

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

Pixel hit by CR

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

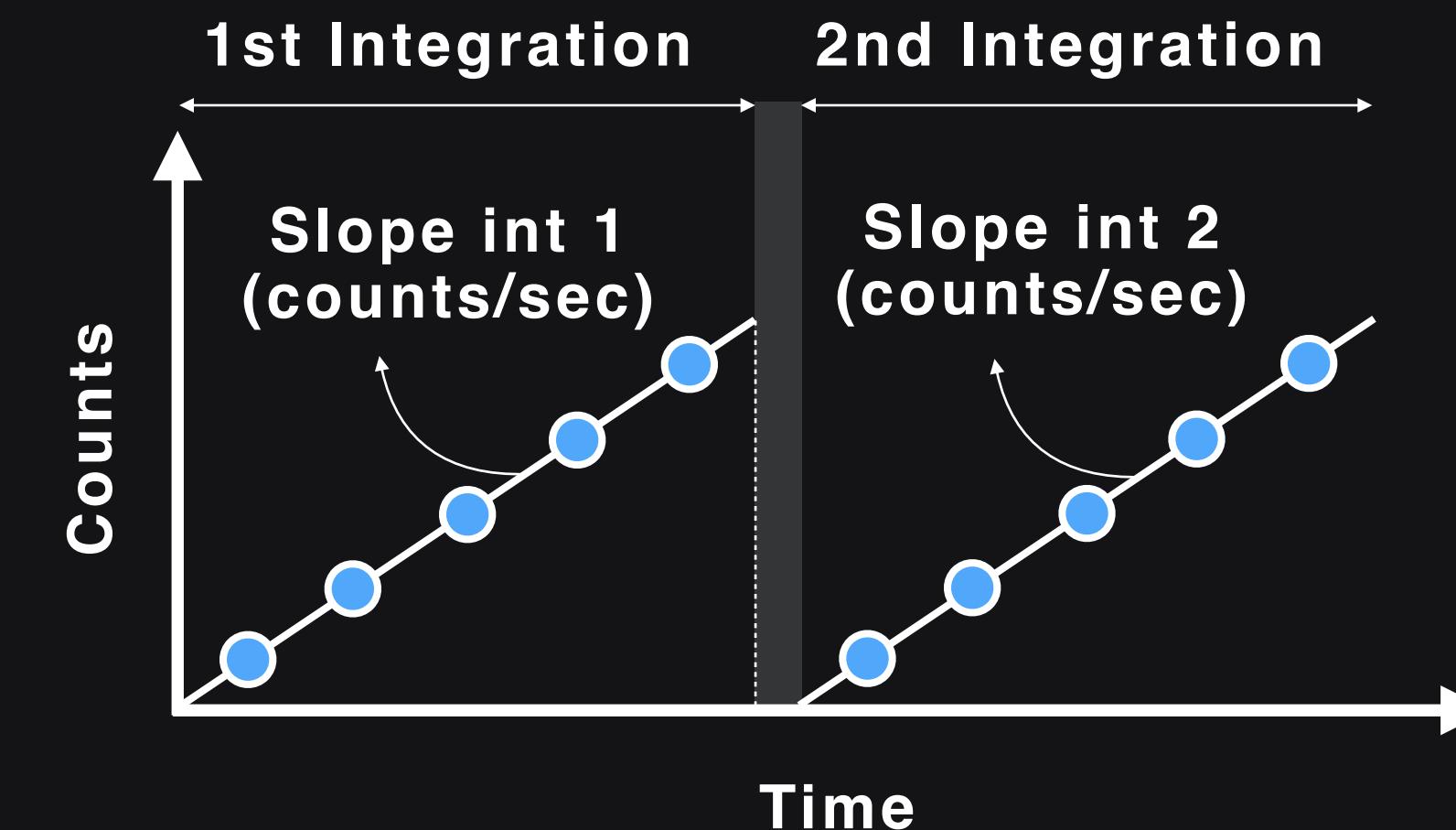
Stage 1 steps, and what to be on the lookout for

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

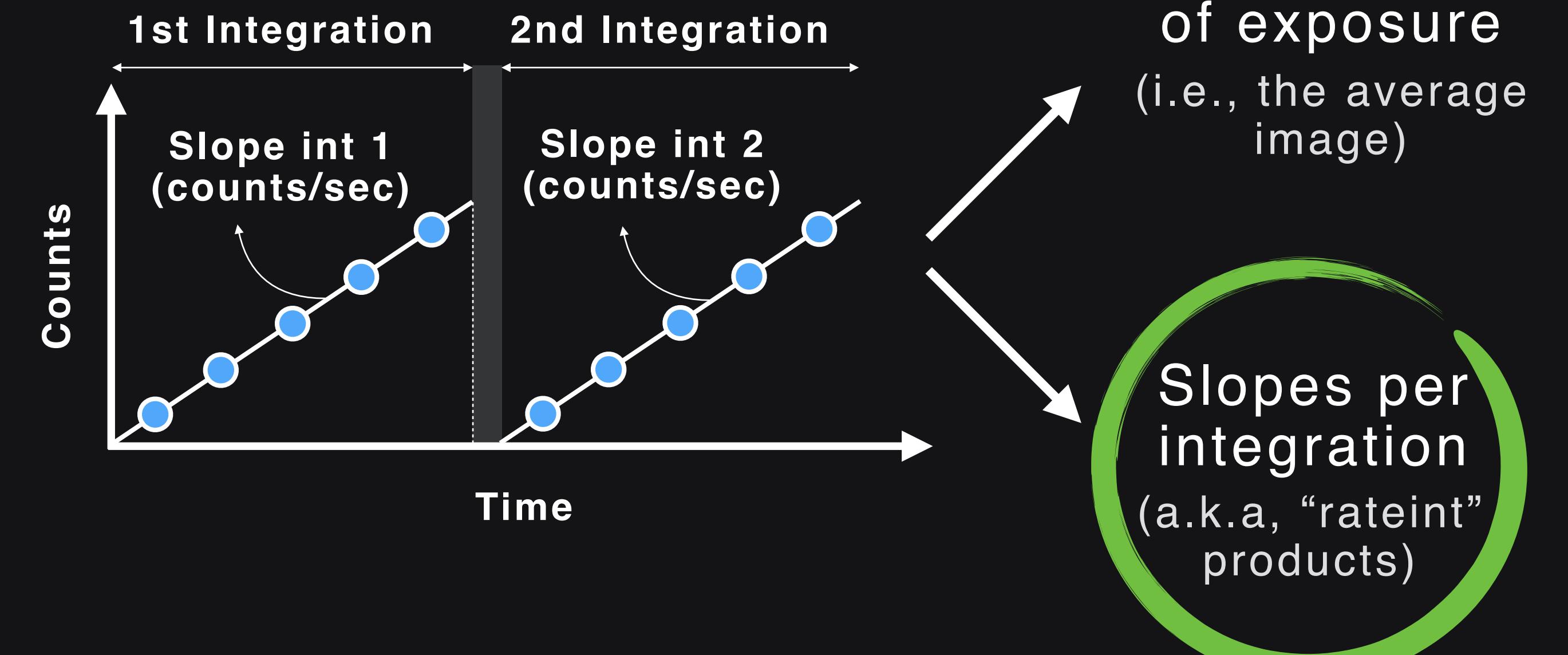
Stage 1 steps, and what to be on the lookout for

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:



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

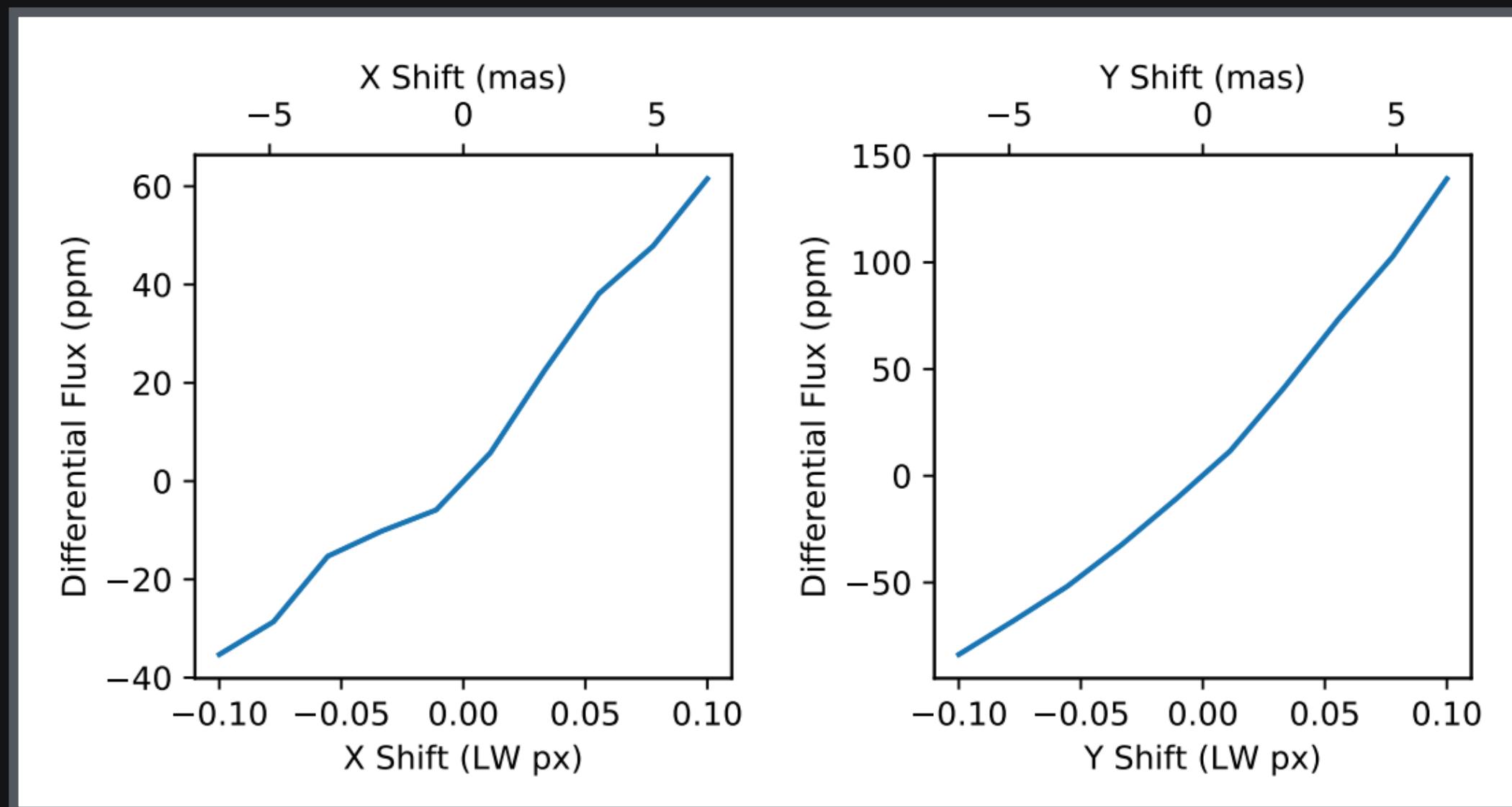
The **ramp_fitting** step obtains the slope on the up-the-ramp samples:



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	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

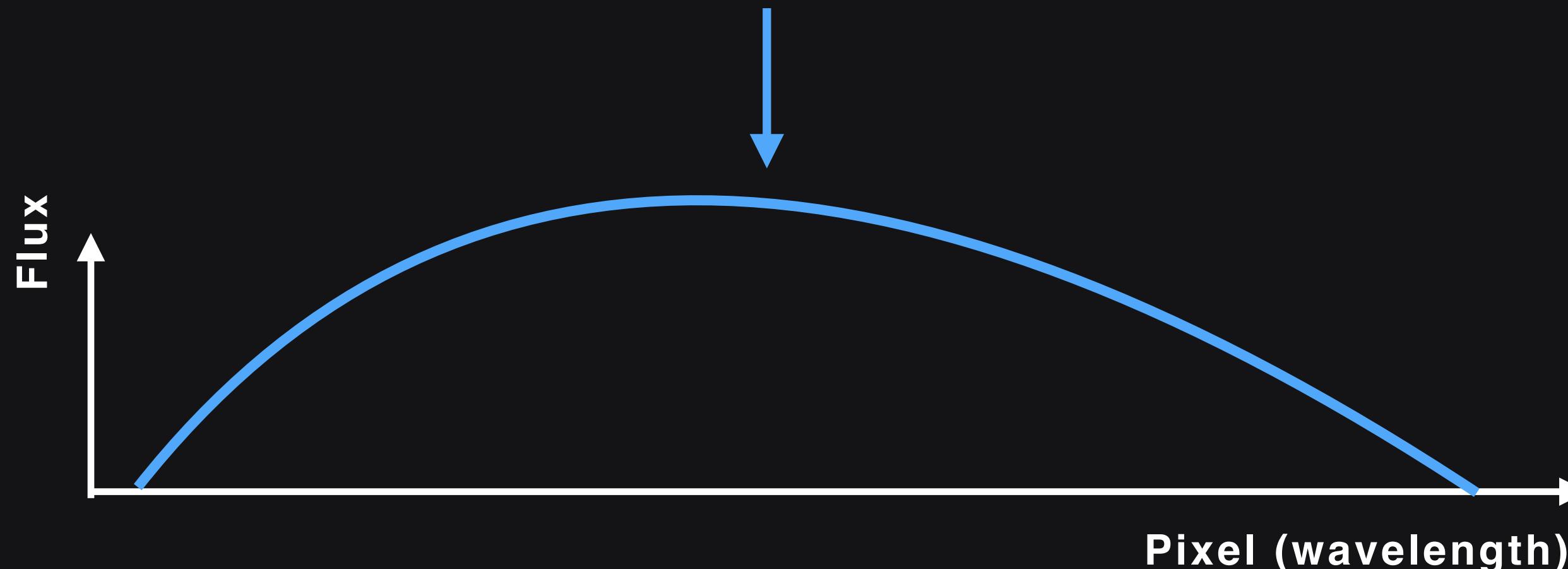
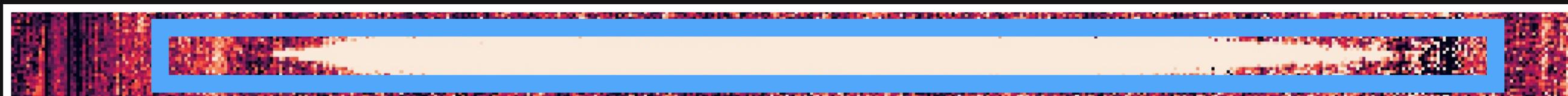
Stage 2 steps

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	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

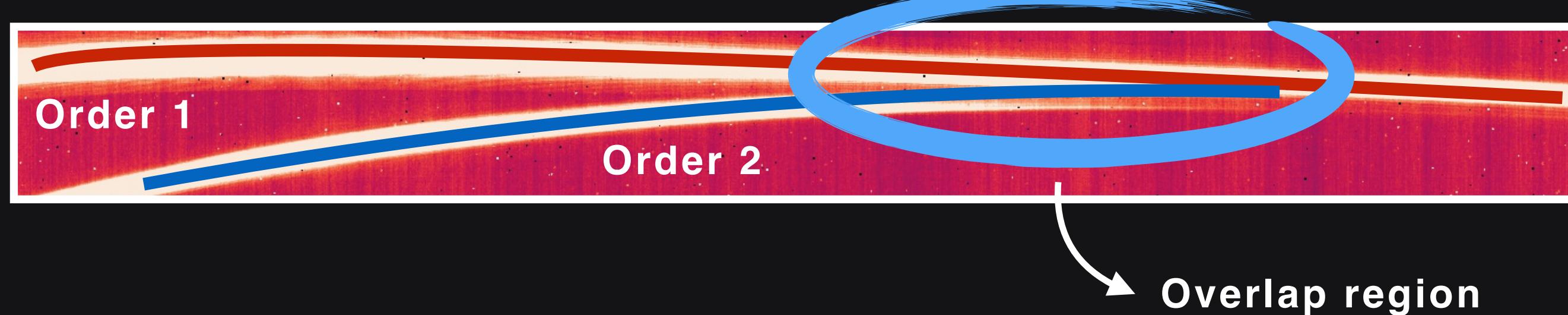
Stage 2 steps

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	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

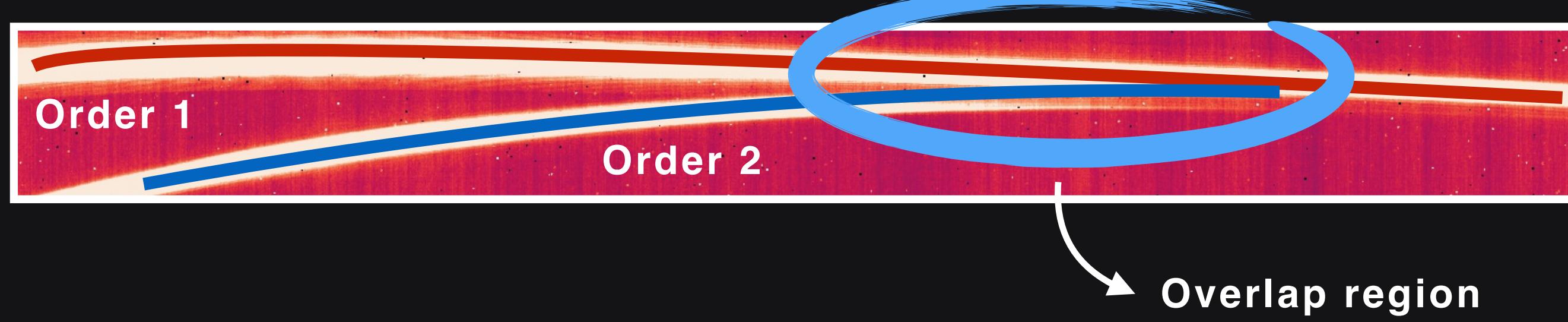
Stage 2 steps

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

Does not work for JWST/NIRISS:



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

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 on 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.