

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

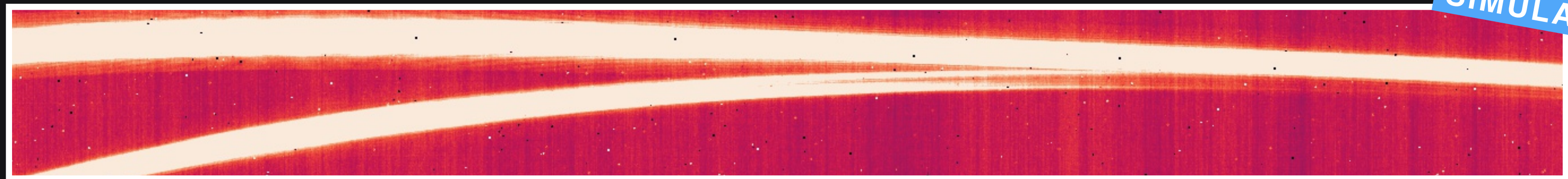
NÉSTOR ESPINOZA |  **STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE



**JWST DATA: WHAT DOES IT LOOK LIKE?**

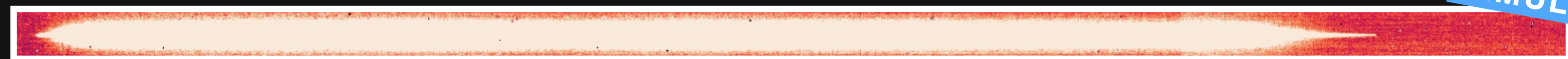


NIRISS



SIMULATED

NIRCAM



SIMULATED



WAVELENGTH

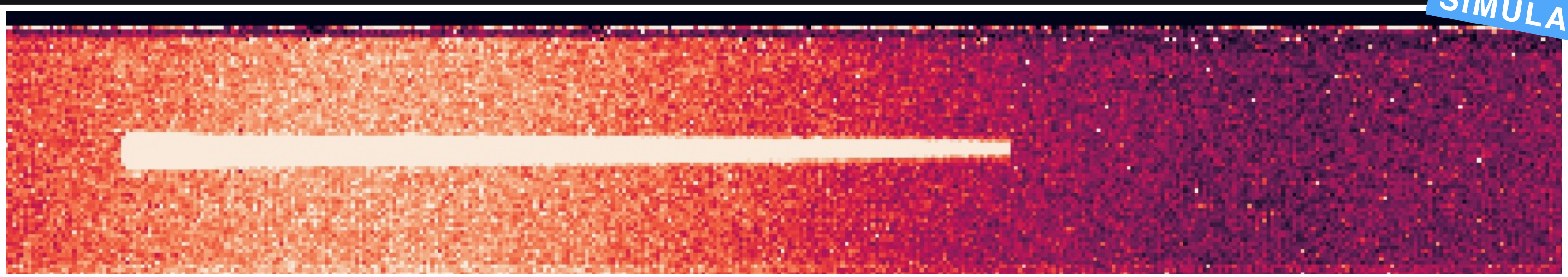
SPECTROSCOPIC  
JWST DATA: WHAT DOES IT LOOK LIKE?

NIRSPEC



GROUND TESTING

MIRI



SIMULATED



NIRISS

**LOOKS OVERWHELMING. HANG IN THERE!**

NIRCAM

AT THE END OF THIS TALK, YOU WILL:

- WAVELENGTH
- 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**.

NIRSPEC

MIRI



# IMPORTANT RESOURCES TO KEEP IN MIND

[jwst-docs.stsci.edu](https://jwst-docs.stsci.edu)

The screenshot shows the 'James Webb Space Telescope User Documentation' website. The header features a hexagonal logo and the title. A navigation bar includes 'Home', 'Quick Links', and a search bar. The left sidebar lists 'Proposing Opportunities' and 'Proposal Preparation'. The main content area, titled 'JWST User Documentation Home', includes a news item about the closure of JWST Cycle 1 General Observer (GO) proposal submissions and a table of proposing tools.

Proposing tools	Current version	Release date
<a href="#">Astronomers Proposal Tool (APT)</a>	2020.5	December 18, 2020
<a href="#">JWST Exposure Time Calculator (ETC)</a>	1.6	March 31, 2021

[jwsthelp.stsci.edu](https://jwsthelp.stsci.edu)

The screenshot shows the 'JWST Help Desk' website. The header includes the STScI logo and navigation links for 'Knowledge', 'Service Portals', 'My Open Tickets', and 'My Open Requests'. The main content area features a large heading 'How can we help?' and a search bar. The footer contains two sections: 'Knowledge Base' with a document icon and 'Get Help' with a person icon.

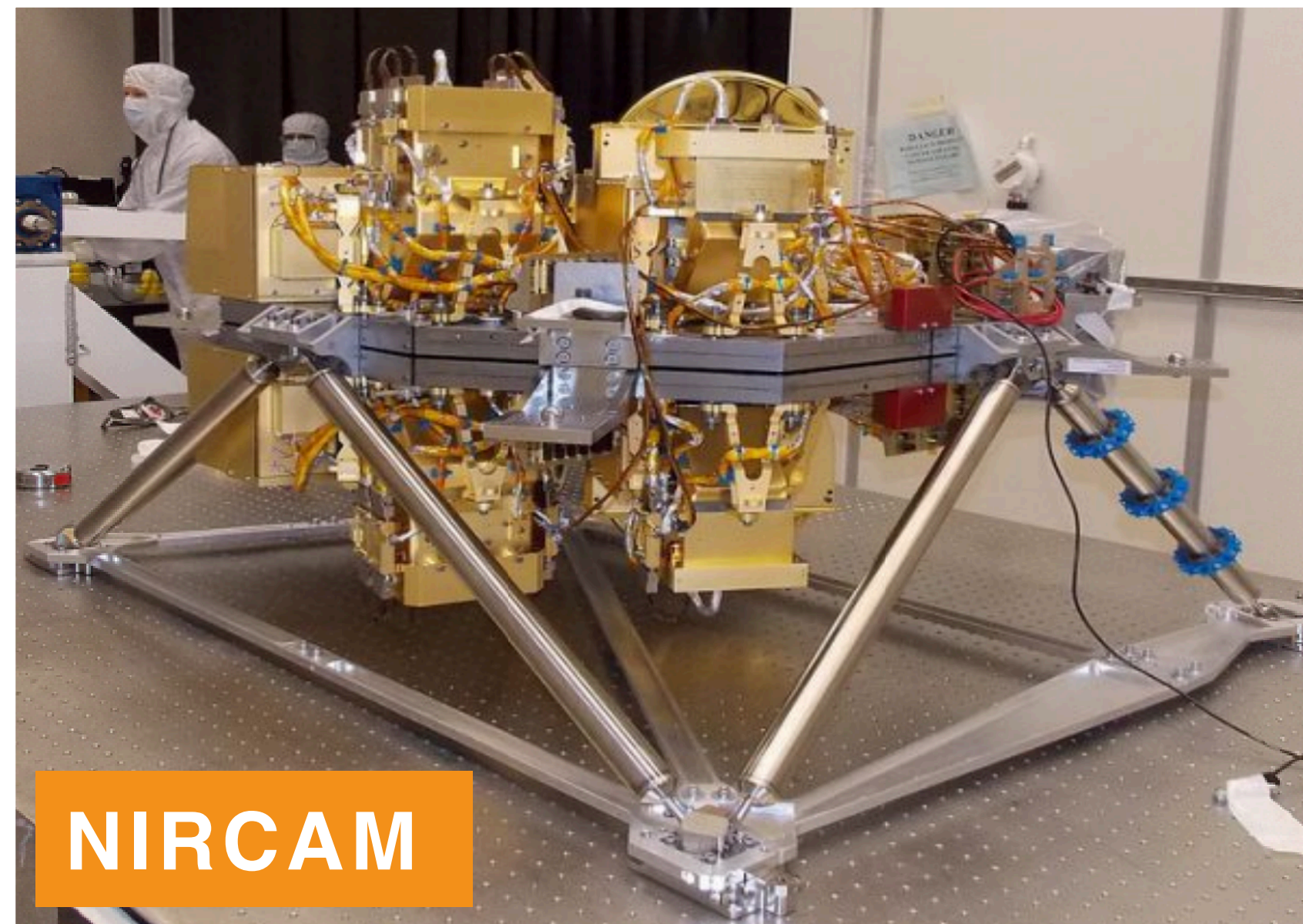


# PART 1

KNOW THY INSTRUMENT, KNOW THY DATA

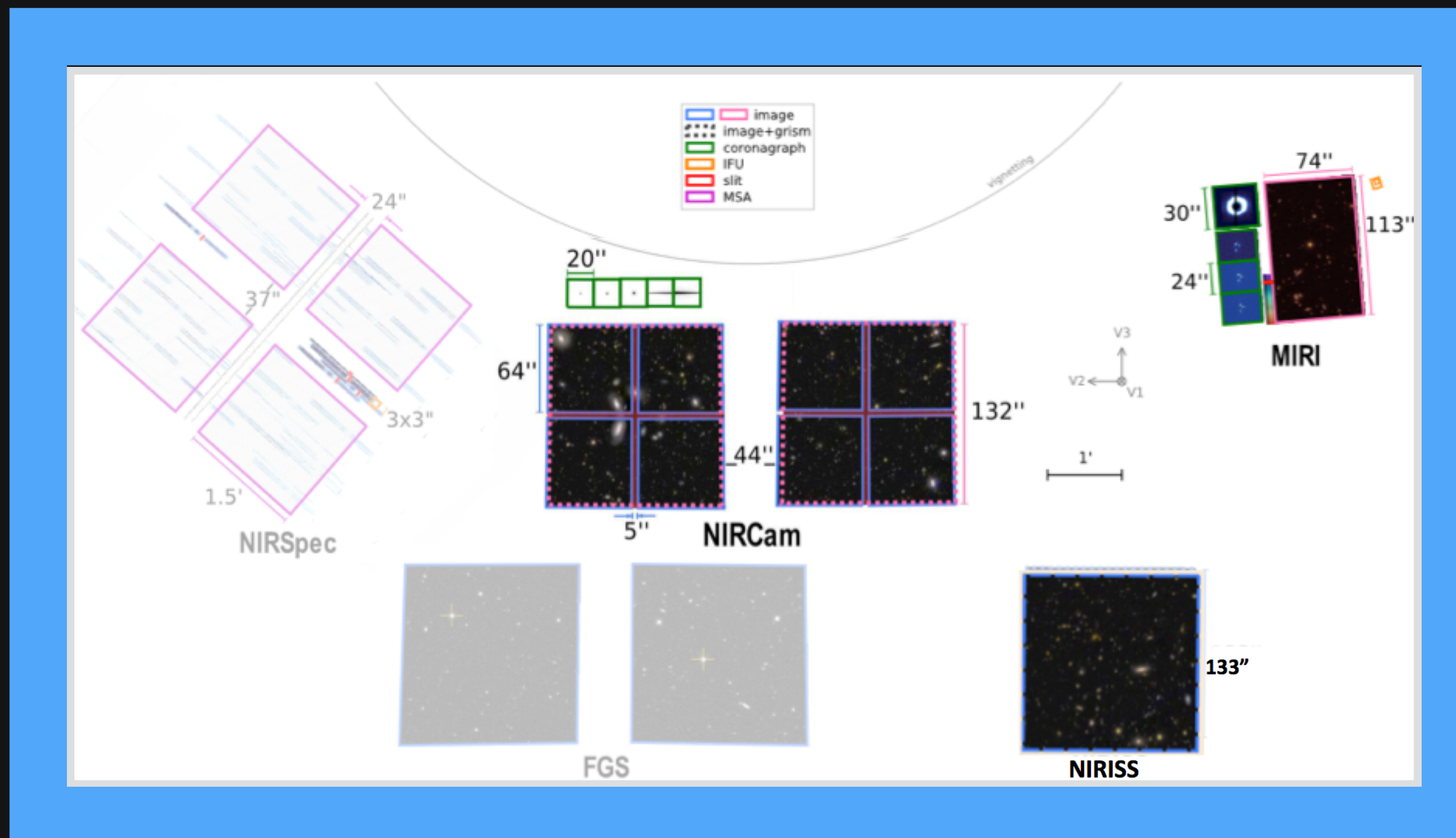


Image credit: Greenhouse (2015, SPIE Proc. Vol. 9602; 960202)





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

0

18.4

28.0

LRS

\*WITH AN INTEGRAL FIELD UNIT (IFU)

**MIRI**



# SPECTROSCOPY WITH



**NIRSPEC**

**NIR INSTRUMENTS**  
(HAWAII-2RG, HgCdTe DETECTORS)

**WHAT YOU'LL LEARN HERE**

(E.G. SIMILAR DETECTORS)

**NIRISS**

**NIRCAM**

**WON'T NECESSARILY TRANSLATE HERE**

**IR INSTRUMENTS**  
(Si:As IBC DETECTORS)

**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

PRO: COMMUNITY HAS QUICK ACCESS TO DATA

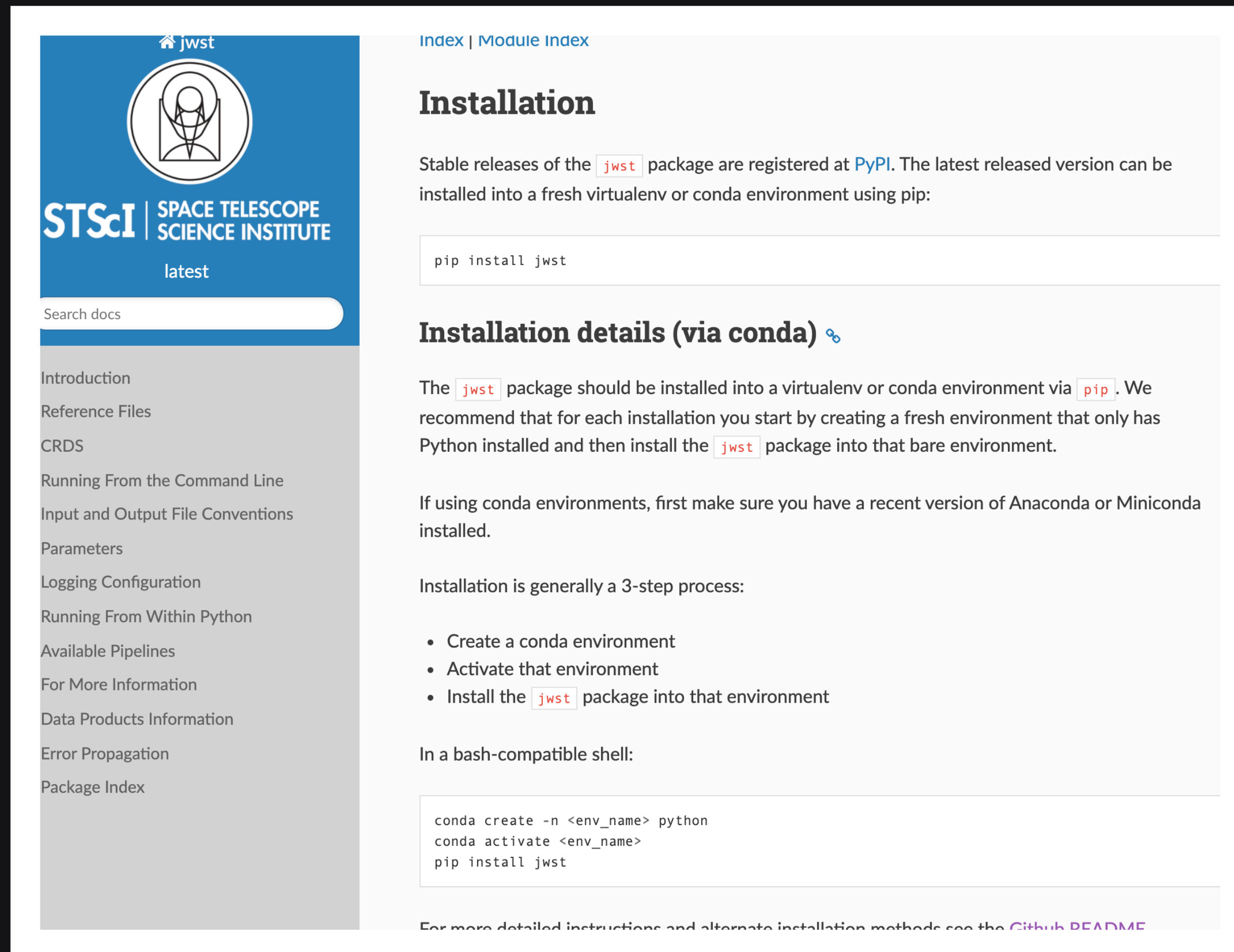
CON: NO PIPELINE WILL BE PERFECT RIGHT AWAY

(AFTER COMMISSIONING)



# THE JWST DATA REDUCTION PIPELINE

[jwst-pipeline.readthedocs.io](https://jwst-pipeline.readthedocs.io)



The screenshot shows the ReadTheDocs page for the JWST pipeline. The left sidebar contains a navigation menu with links: Introduction, Reference Files, CRDS, Running From the Command Line, Input and Output File Conventions, Parameters, Logging Configuration, Running From Within Python, Available Pipelines, For More Information, Data Products Information, Error Propagation, and Package Index. The main content area is titled 'Installation' and includes a 'Stable releases' section with a link to PyPI. Below this is a code block for installing the package via pip. The 'Installation details (via conda)' section explains the recommended installation process, including creating a fresh environment and installing the package. A code block shows the conda and pip commands for this process. At the bottom, there is a link to the GitHub README for more detailed instructions.

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](#)

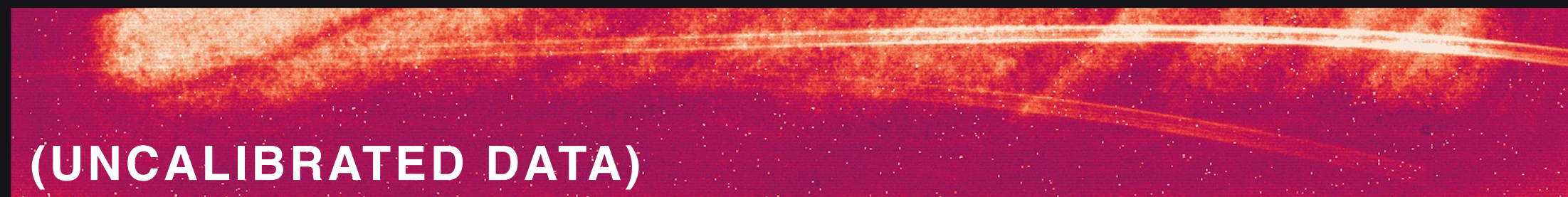
- Really, *a* JWST pipeline.
- Coded in **Python**. Modular. Open source.
- Algorithms tailored to particular instruments and modes.
- Has direct input from JWST instrument teams.
- Currently under active development at STScI.

\*TSO: Time-Series Observation

# THE JWST DATA REDUCTION PIPELINE

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

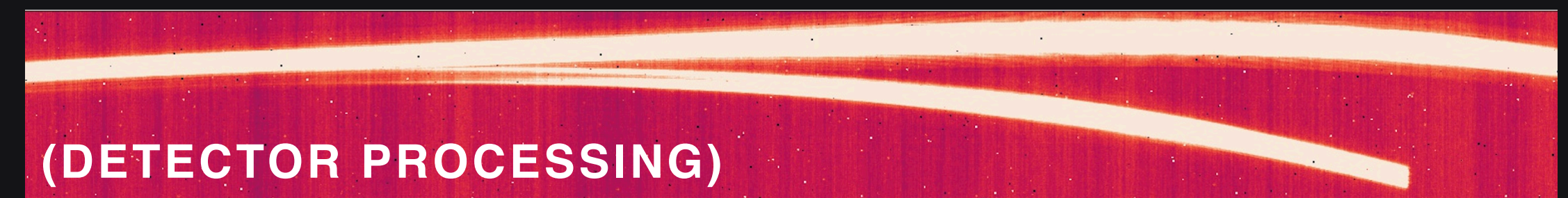
## STAGE 0:



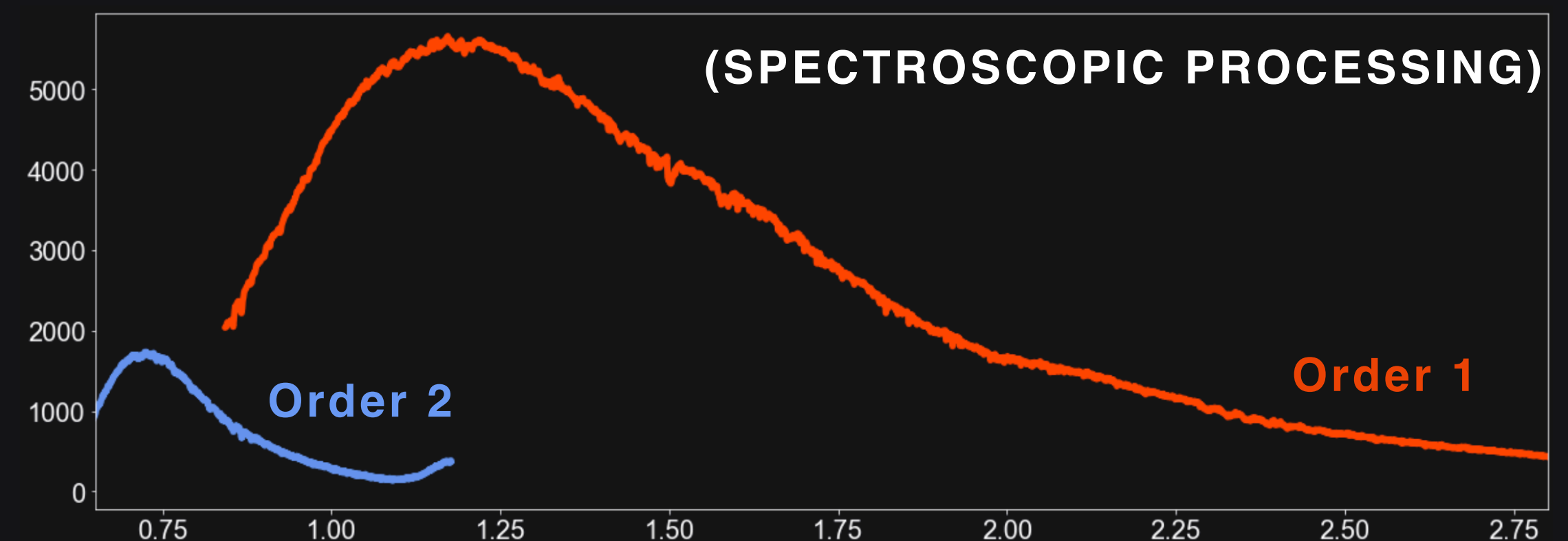
Simulated uncalibrated (\*.uncal.fits) NIRISS/SOSS data



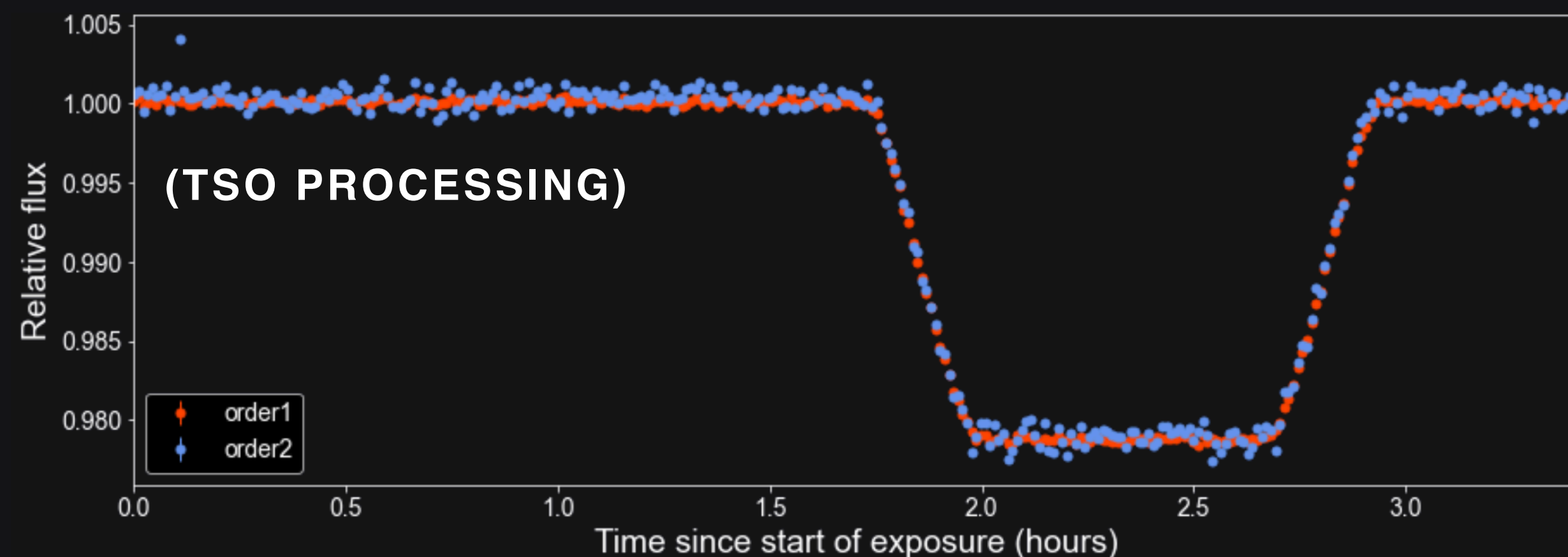
## AFTER STAGE 1:



## AFTER STAGE 2:



## AFTER STAGE 3:



Wavelength (microns)



\*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)

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

**PRODUCTS AT ALL STAGES  
WILL BE AVAILABLE!**

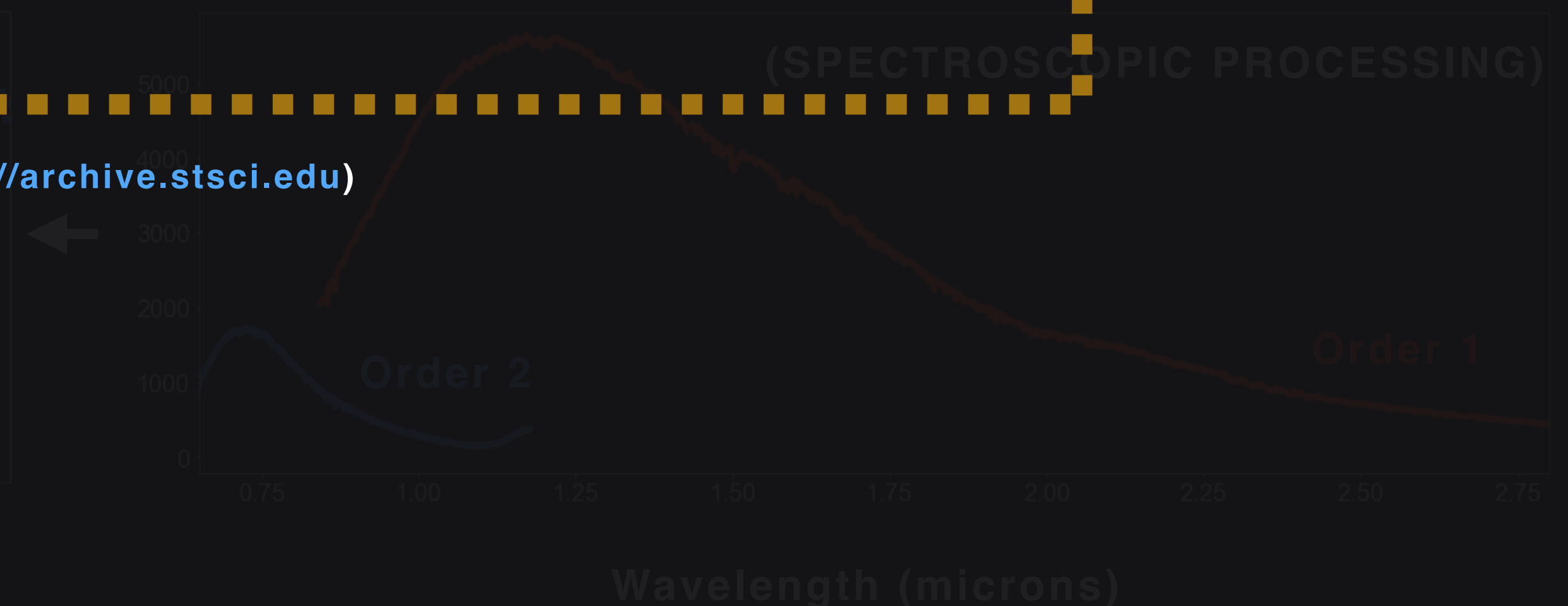
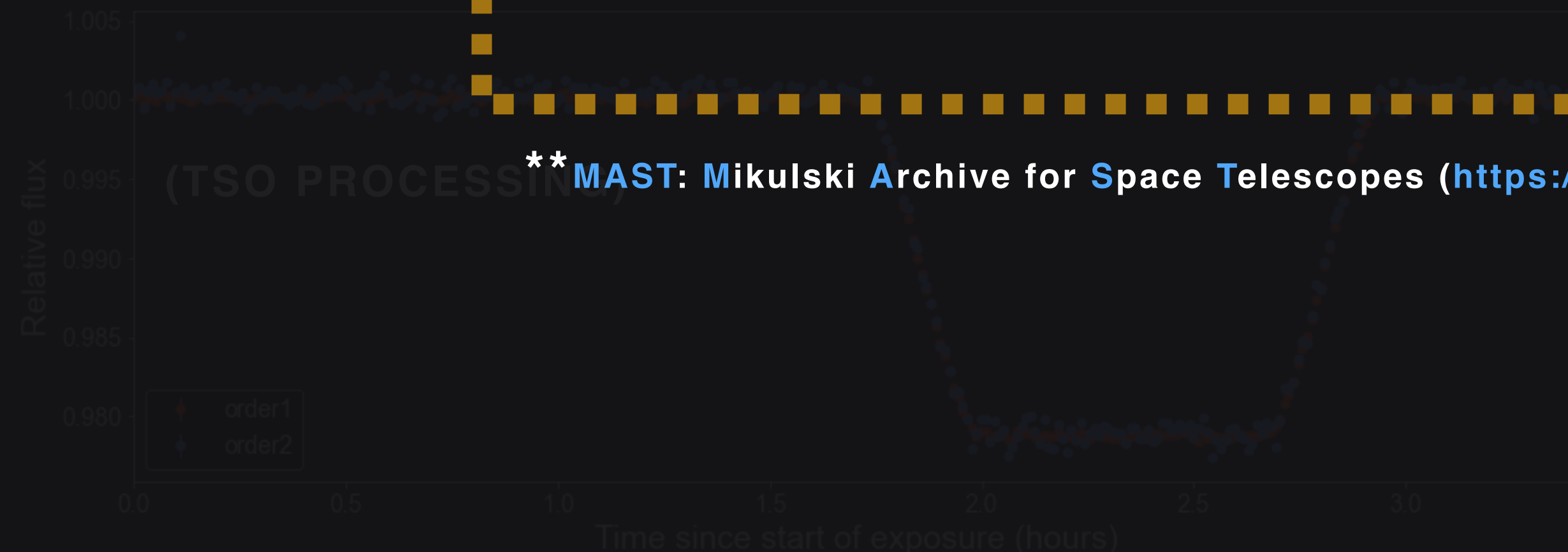
AFTER STAGE 3:

AFTER STAGE 2:

(SPECTROSCOPIC PROCESSING)

(TSO PROCESSING)











\*\* **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


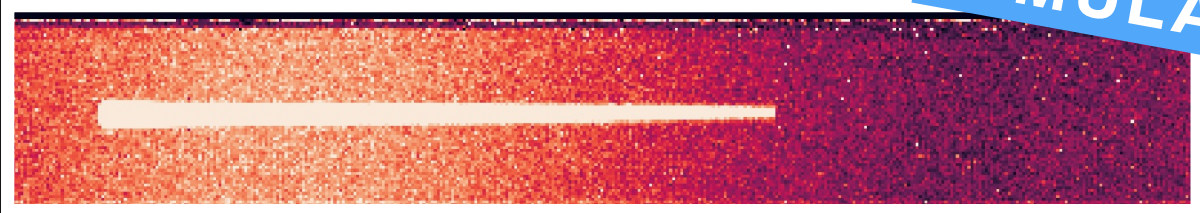

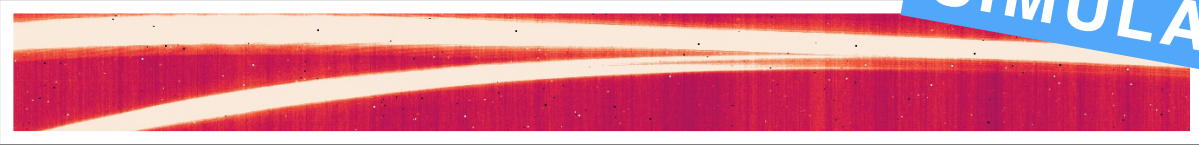


# THE SIMULATED ERS DATASETS

(Nintegrations, Nggroups, Pixel, Pixel)

(Nintegrations, Pixel, Pixel)

(Nintegrations, Pixel)

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

# PART 3

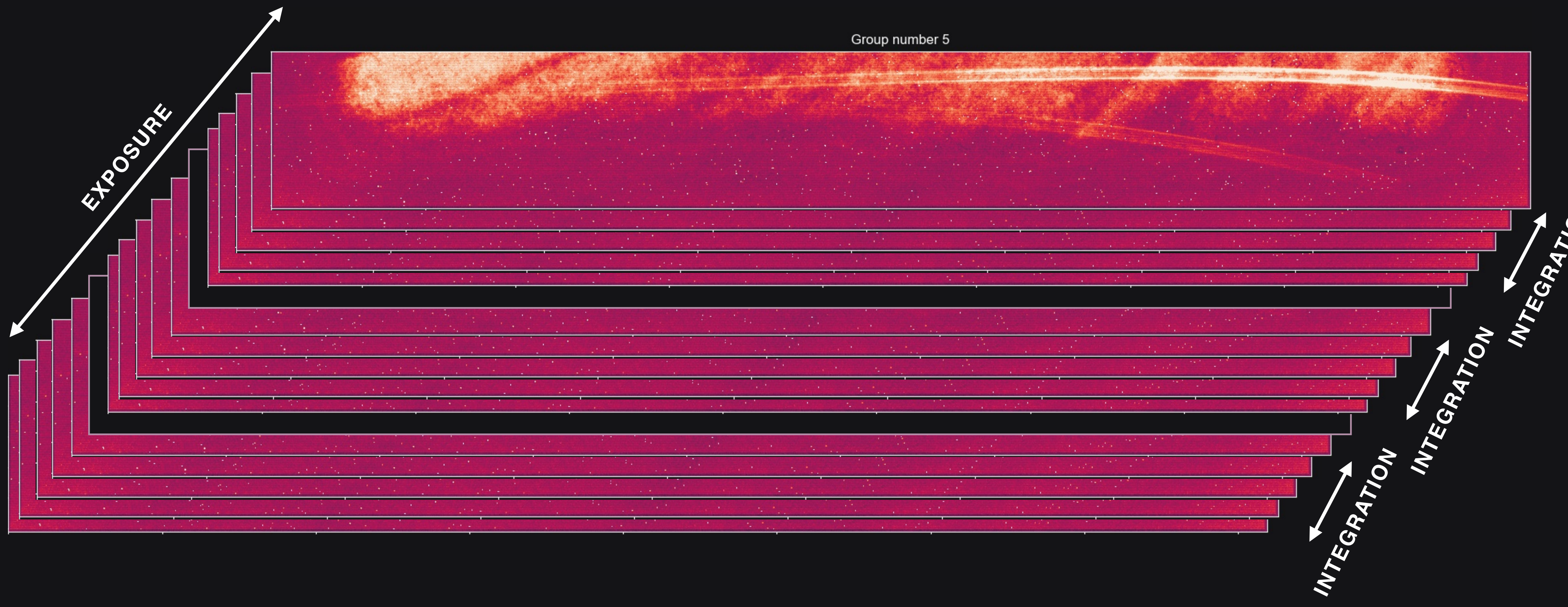
HOW THE JWST PIPELINE WORKS, AND WHAT TO EXPECT



# JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)



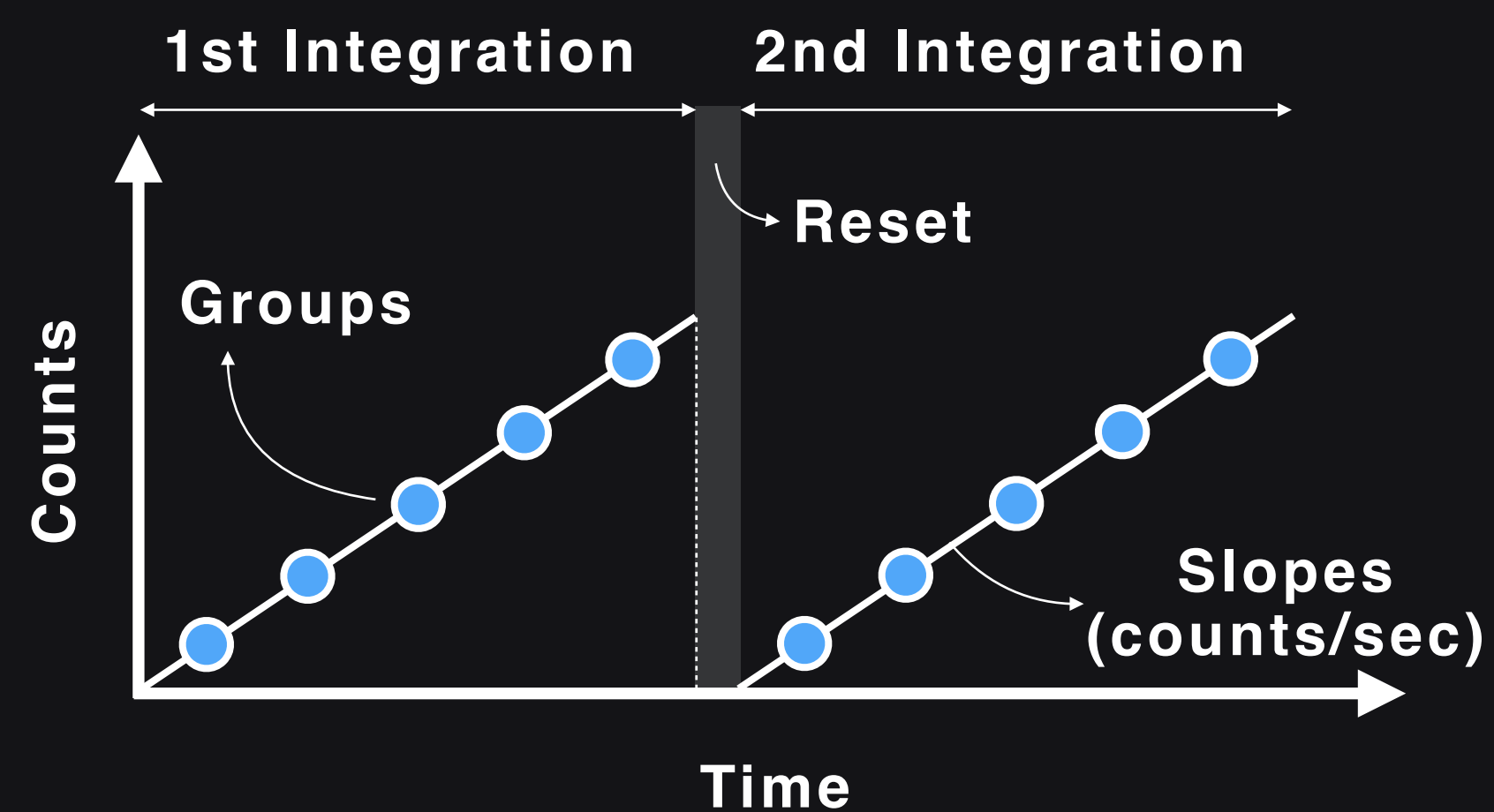


# JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

## A normal pixel



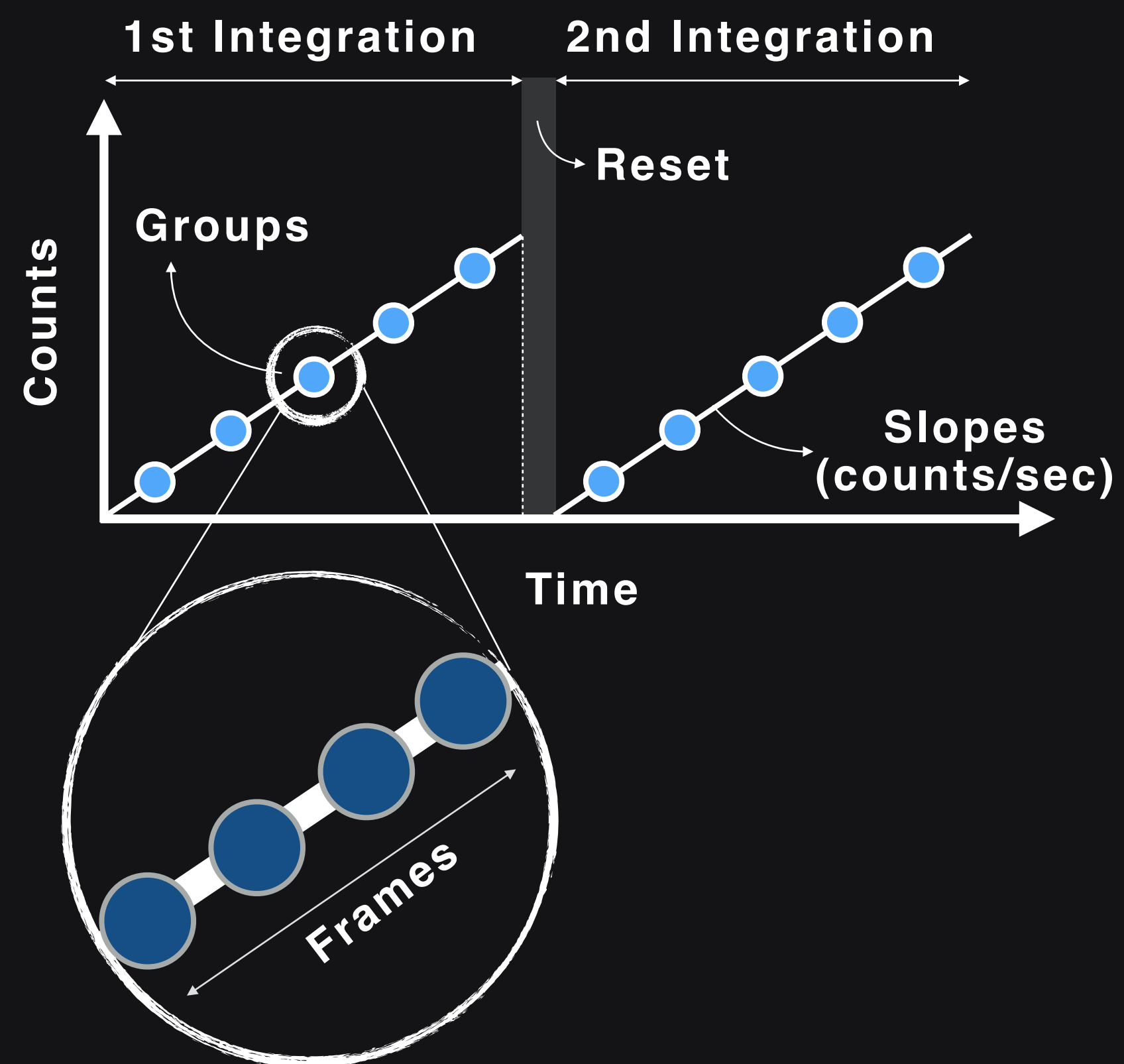


# JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

## A normal pixel

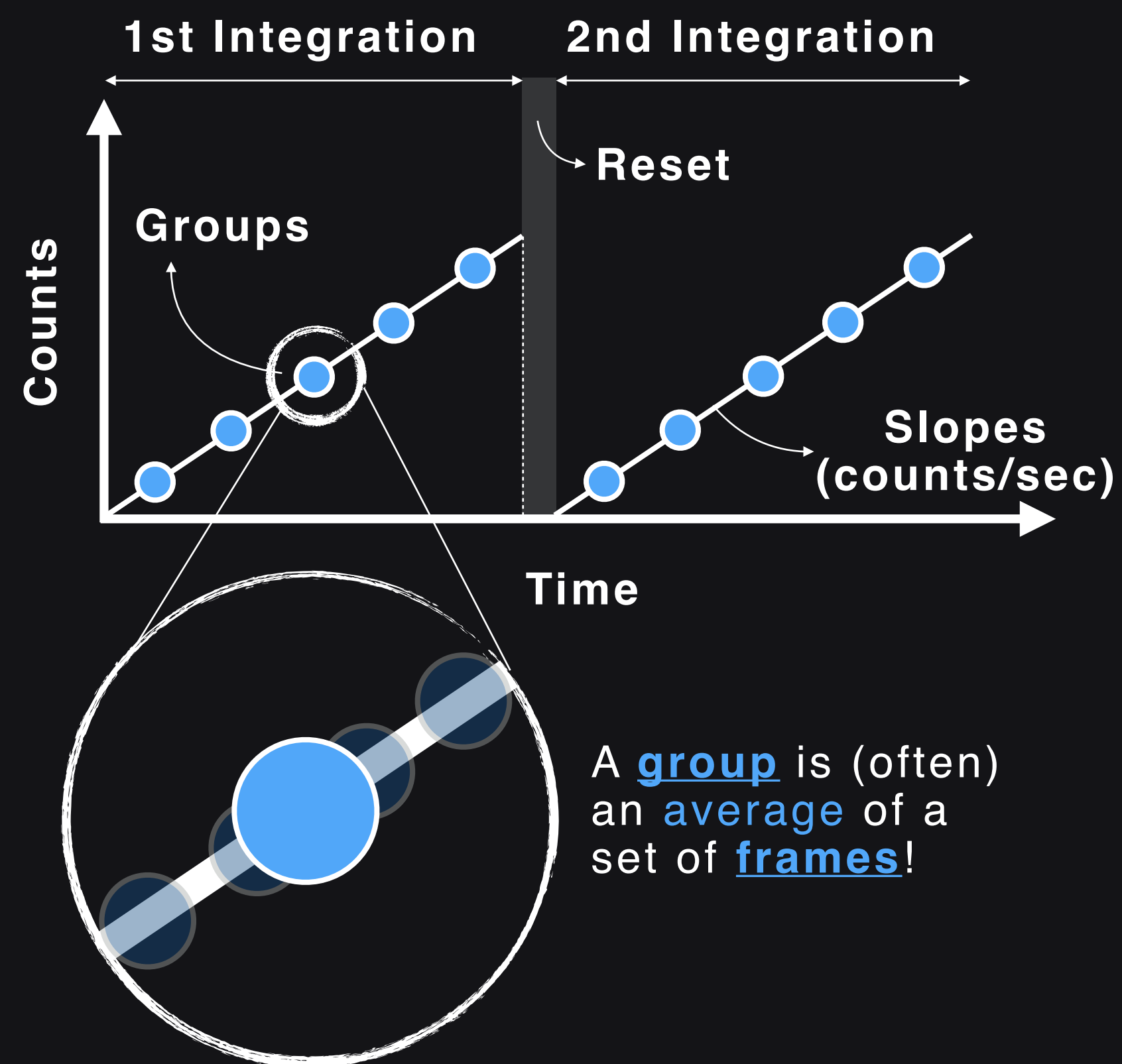


# JWST DETECTORS READOUT 101

The JWST detectors up-the-ramp readout method

(a.k.a. MULTIACCUM)

## A normal pixel

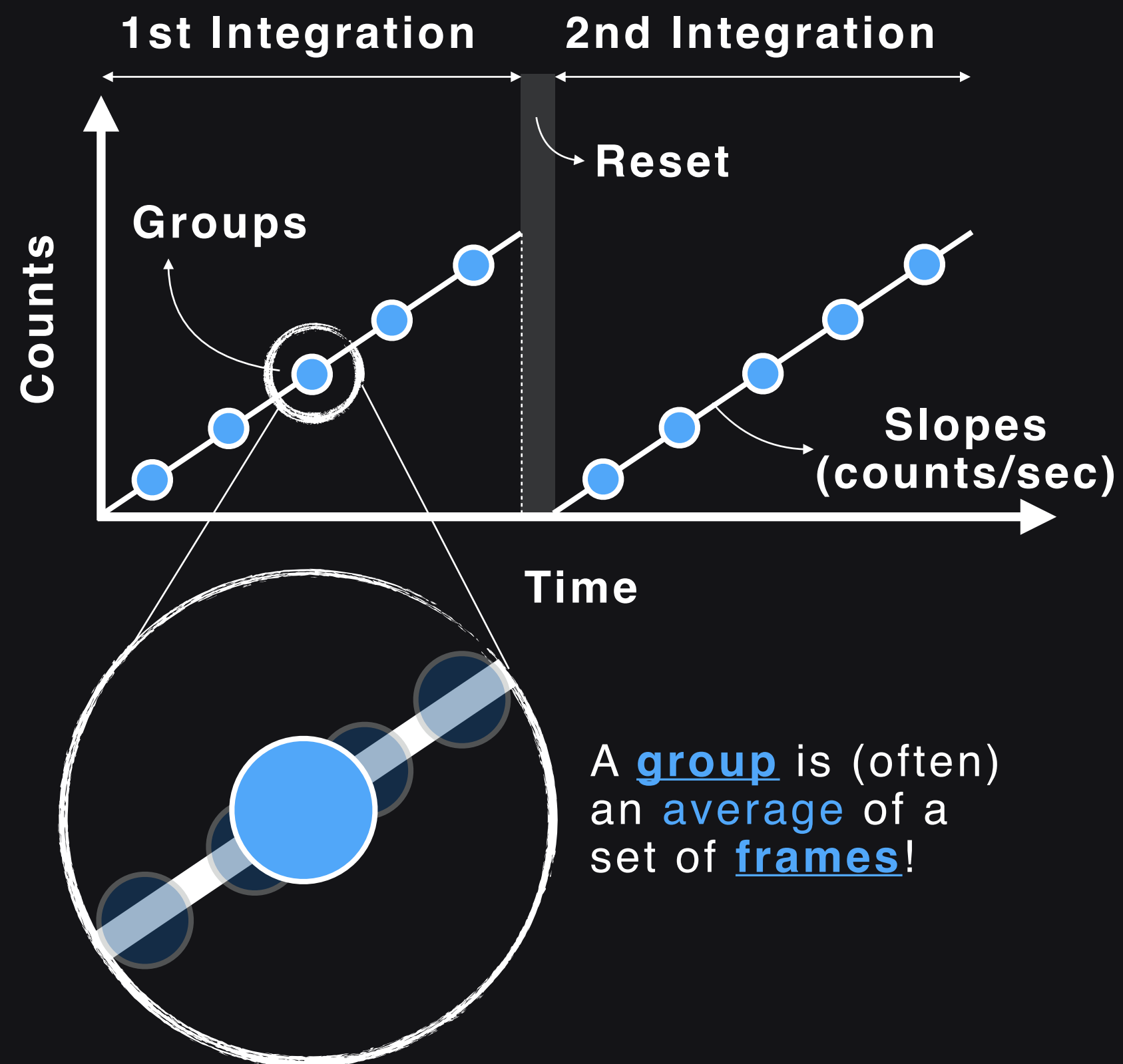




# JWST DETECTORS READOUT 101

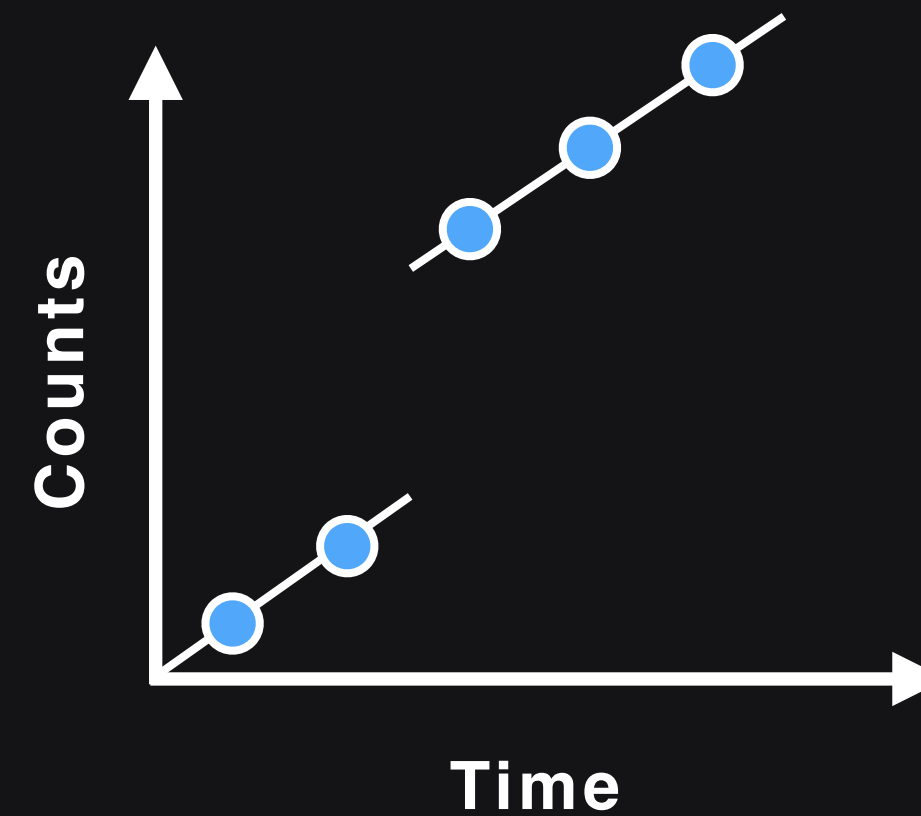
The JWST detectors up-the-ramp readout method  
(a.k.a. MULTIACCUM)

## A normal pixel



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

## Pixel hit by CR



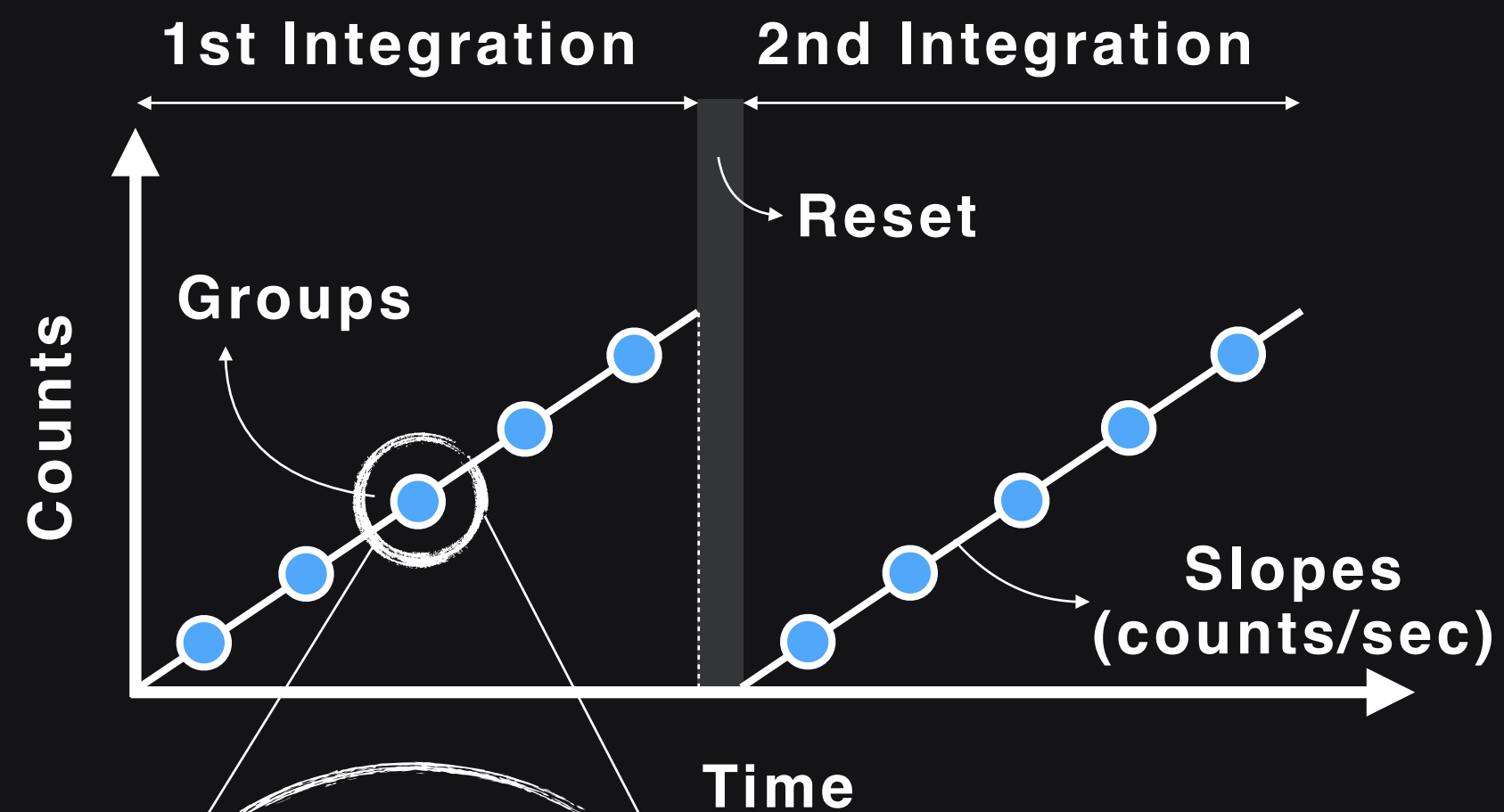
Cosmic rays can be modeled as “jumps” in an up-the-ramp sample.

# JWST DETECTORS READOUT 101

## The JWST detectors up-the-ramp readout method

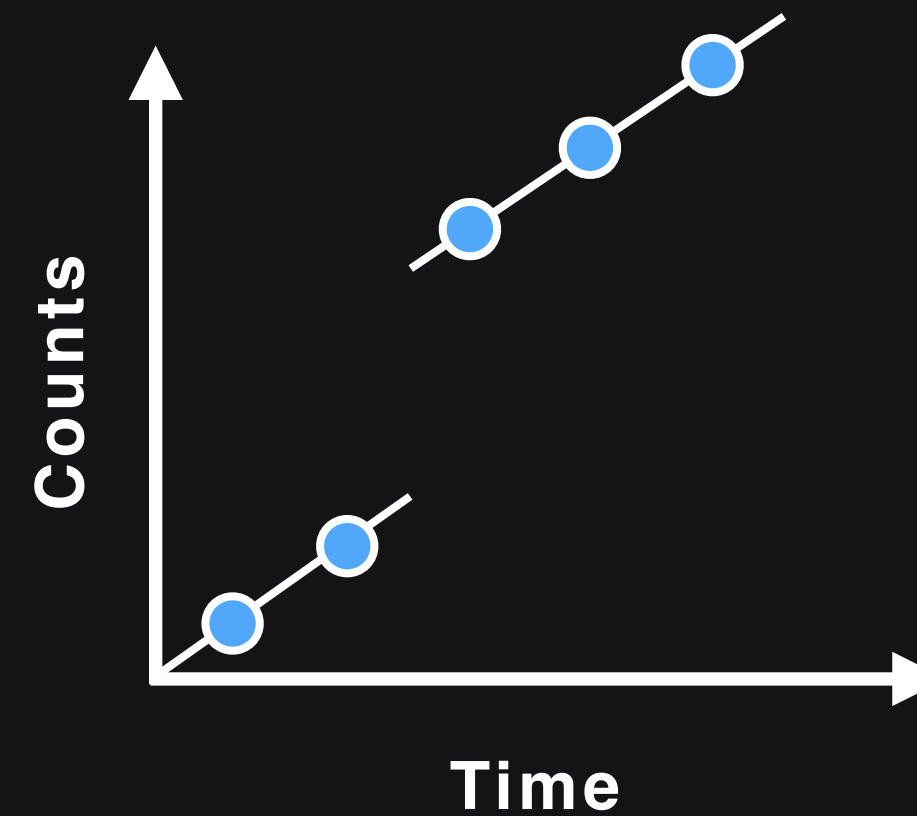
(a.k.a. MULTIACCUM)

### A normal pixel



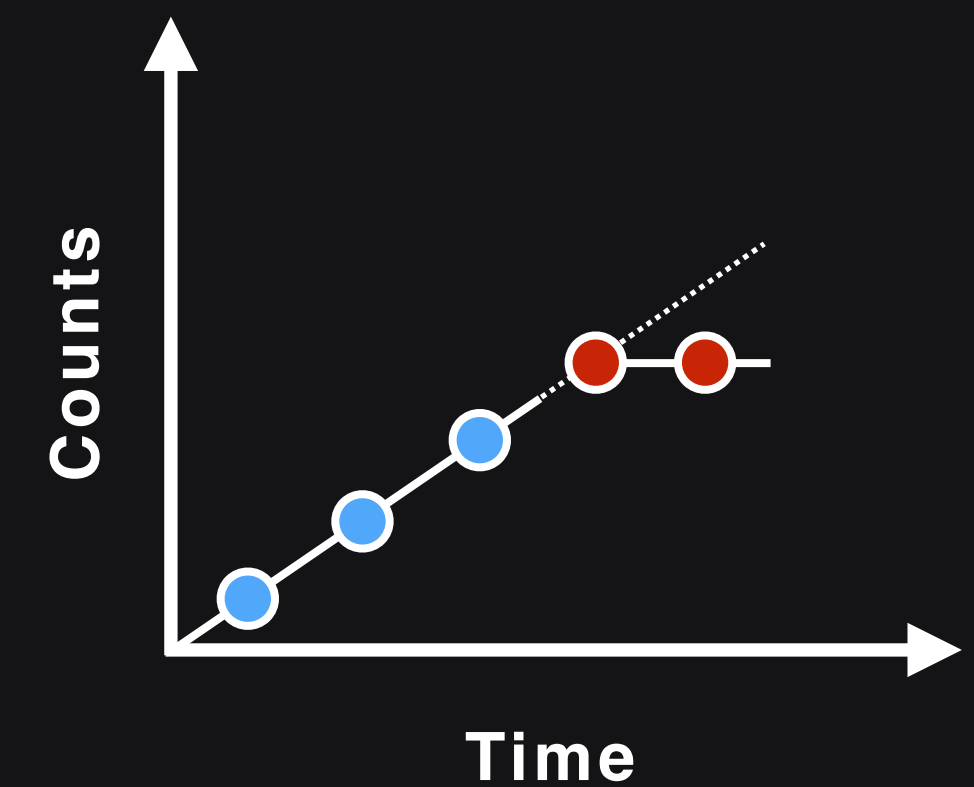
A **group** is (often) an **average** of a set of **frames**!

### 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](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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](https://jwst-crds.stsci.edu)

### JWST Calibration Reference Data System (CRDS)

Obtain Best Reference Files

- Using the Command Line
- From Dataset ID or FITS Header Upload
- Exploring with Instrument Parameters

Reference File Database Services

- Browse Database
- 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 NIRCcam gain and photom reference files.
2021-06-03	jwst_0732.pmap	archived	Reverted the NIRCcam 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 NIRCcam. Initial delivery of MIRI whitelight step parameter reference files. Update to NIRCcam 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 GRISM and GRISM, and exposure types other than NRC_WFSS and NRC_TSGRISM. New NIRCcam specwcs reference files.
2021-05-21	jwst_0723.pmap	archived	Updated rmaps for NIRCcam 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

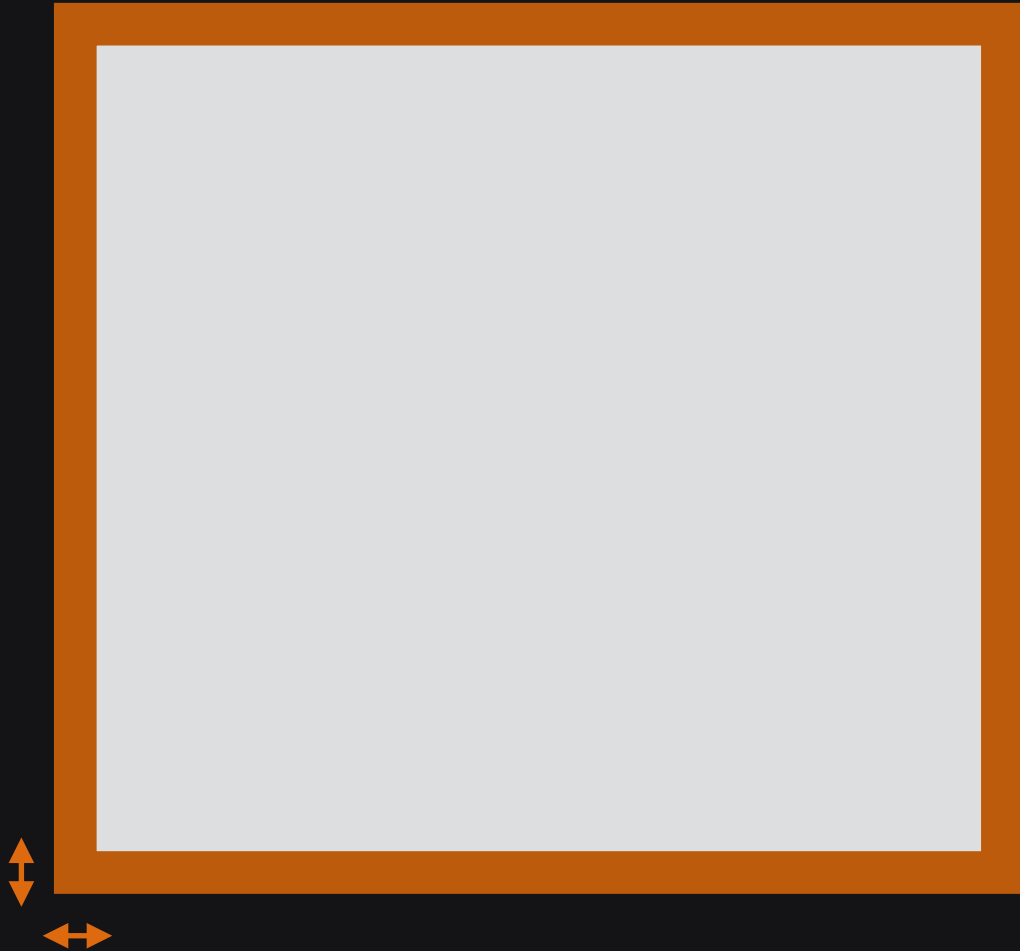
[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

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

Stage 1 **steps**

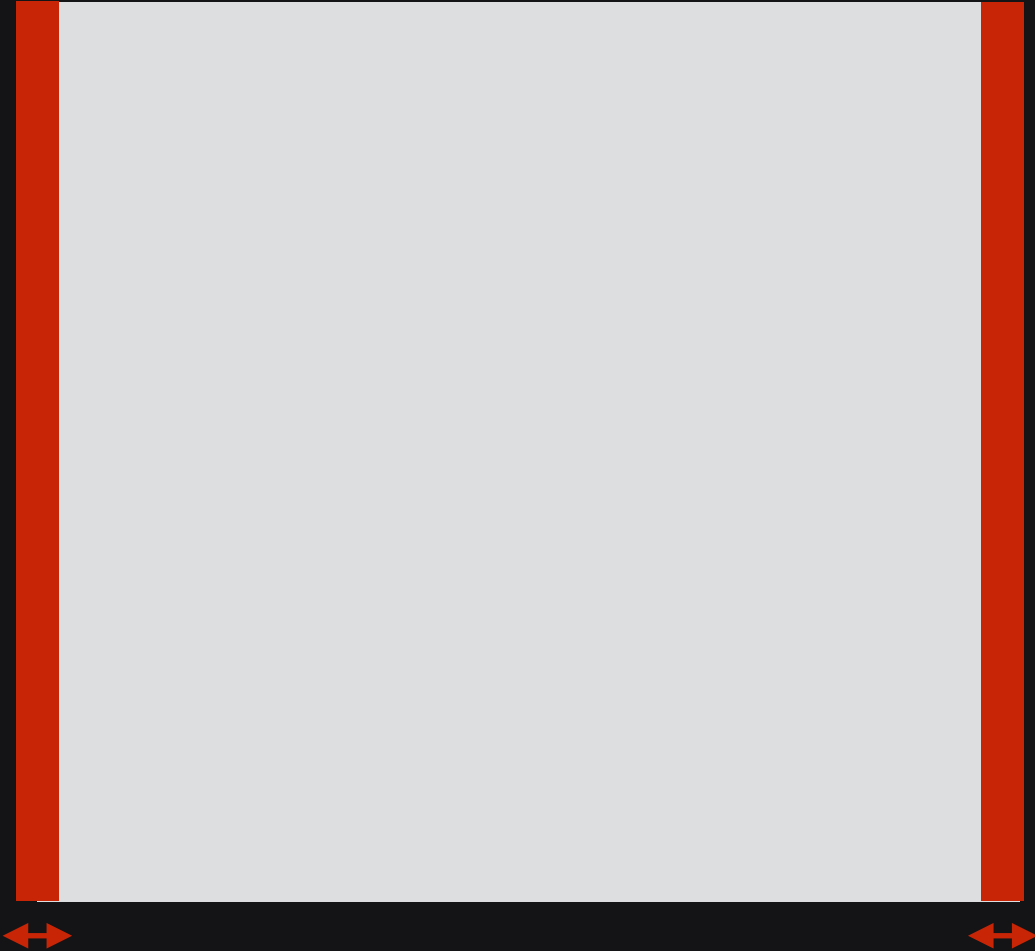
The **refpix** step aims to correct detector variations using **reference pixels**:

(i.e., NIRISS, NIRCам, 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

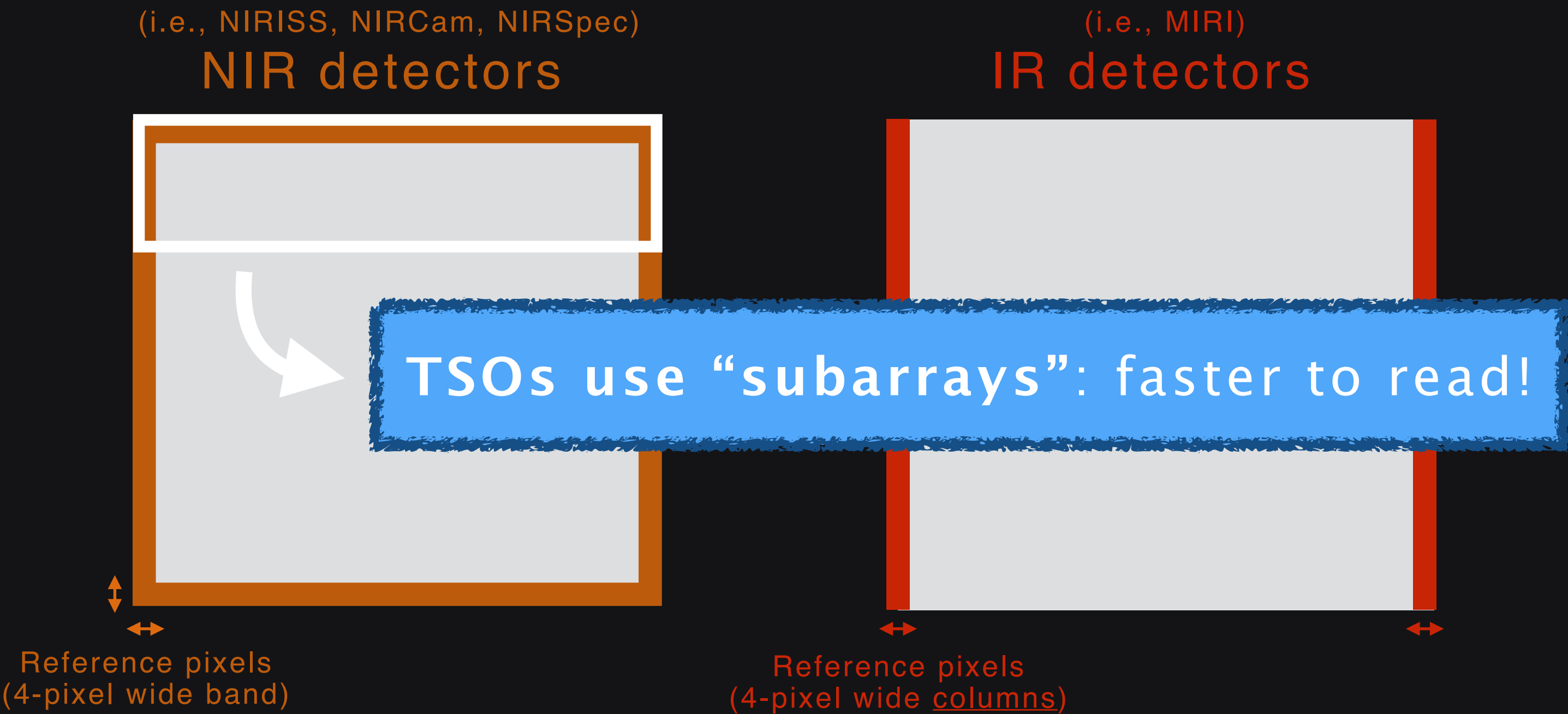
Stage 1 steps, and what to be on the lookout for

[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

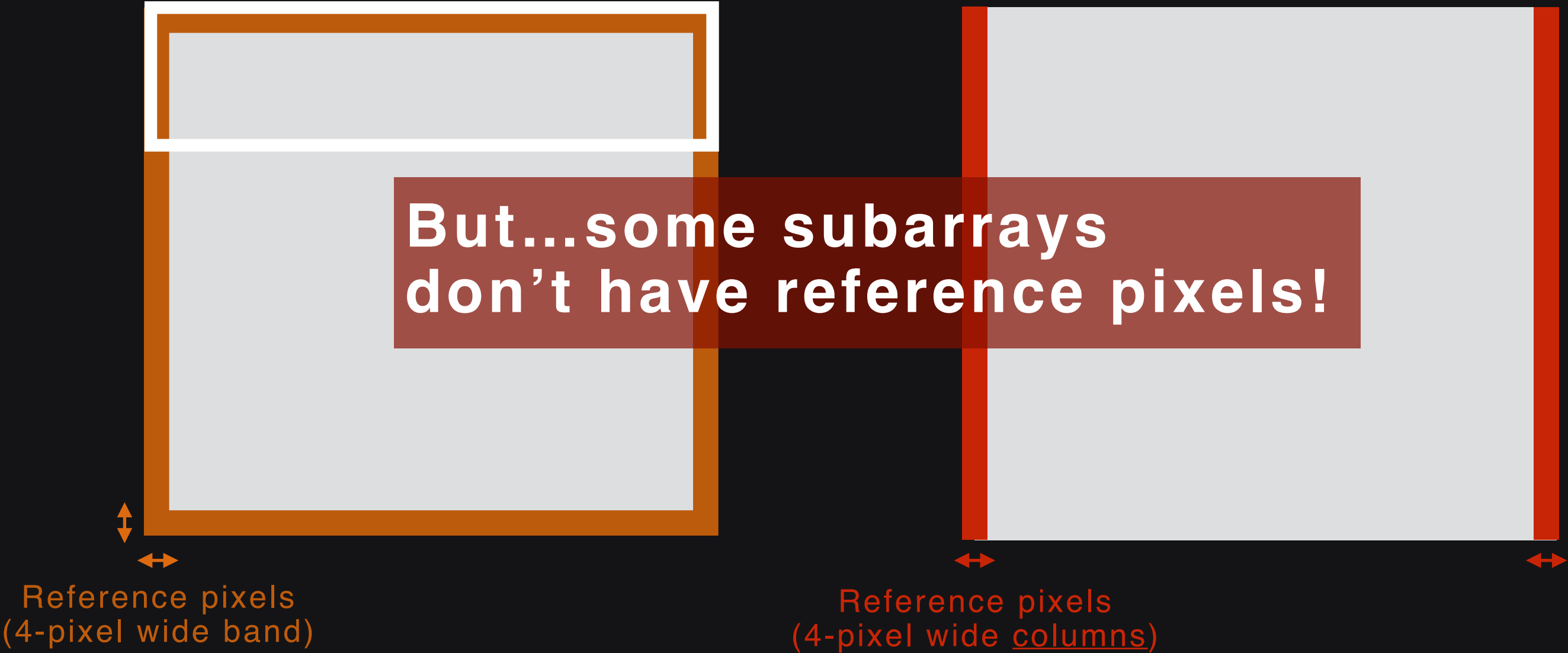
Near-IR			MIRI		
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			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, NIRCам, NIRSpec)  
NIR detectors

(i.e., MIRI)  
IR detectors





# THE JWST DATA REDUCTION PIPELINE

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

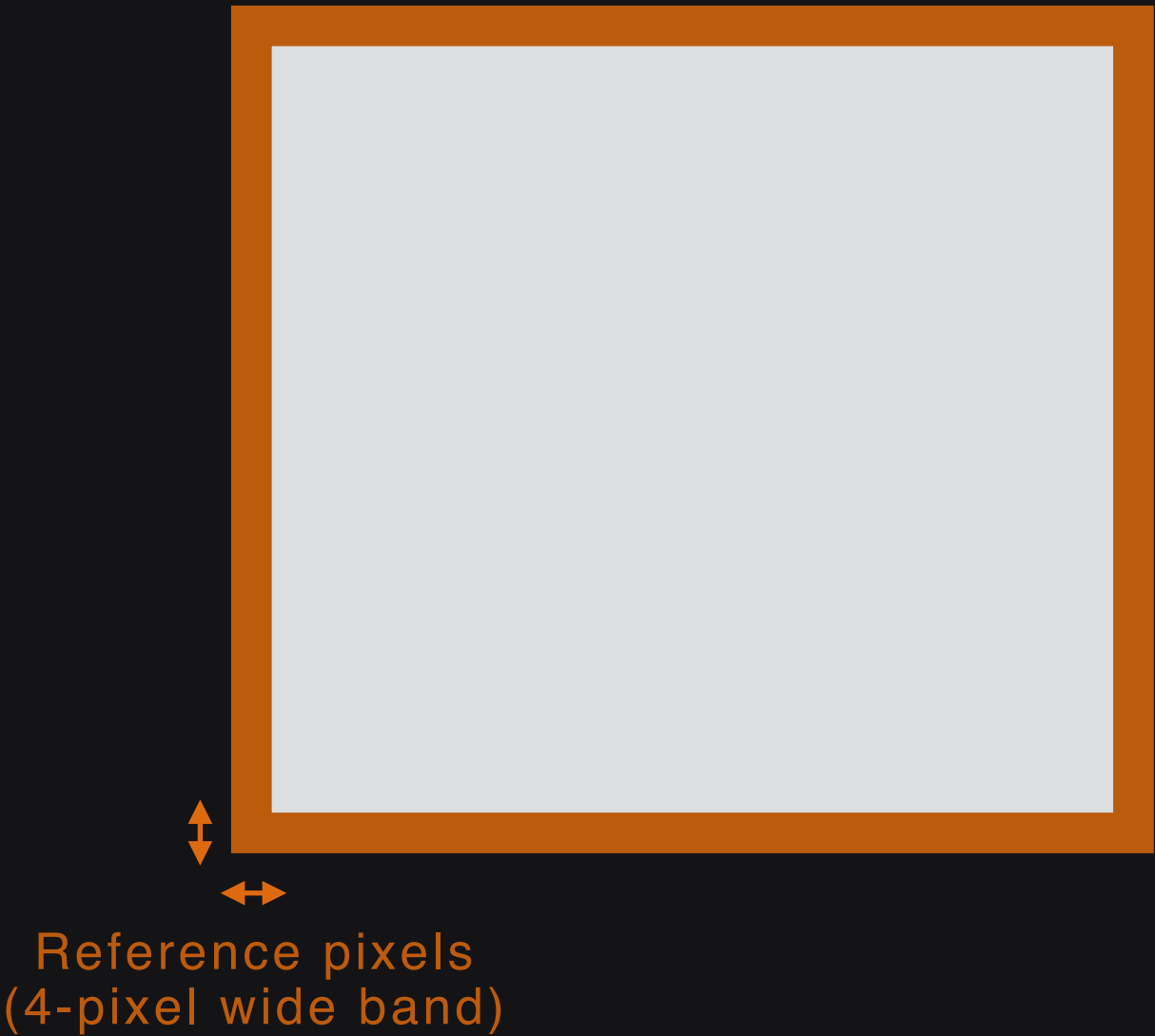
[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

Near-IR			MIRI		
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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, NIRCам, NIRSpec)  
NIR detectors



(i.e., MIRI)  
IR detectors



# THE JWST DATA REDUCTION PIPELINE

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

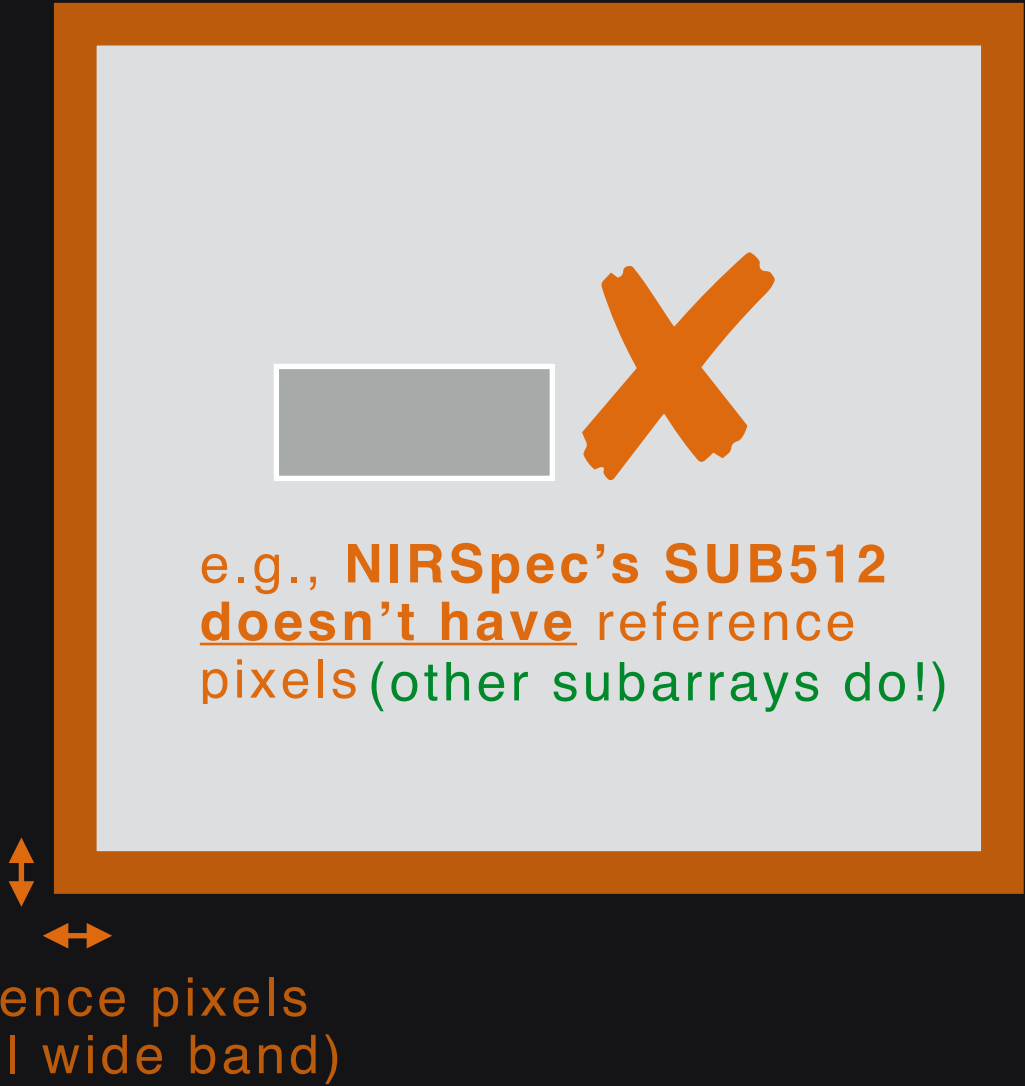
[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

Near-IR			MIRI		
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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, NIRCам, NIRSpec)  
NIR detectors



(i.e., MIRI)  
IR detectors





# THE JWST DATA REDUCTION PIPELINE

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

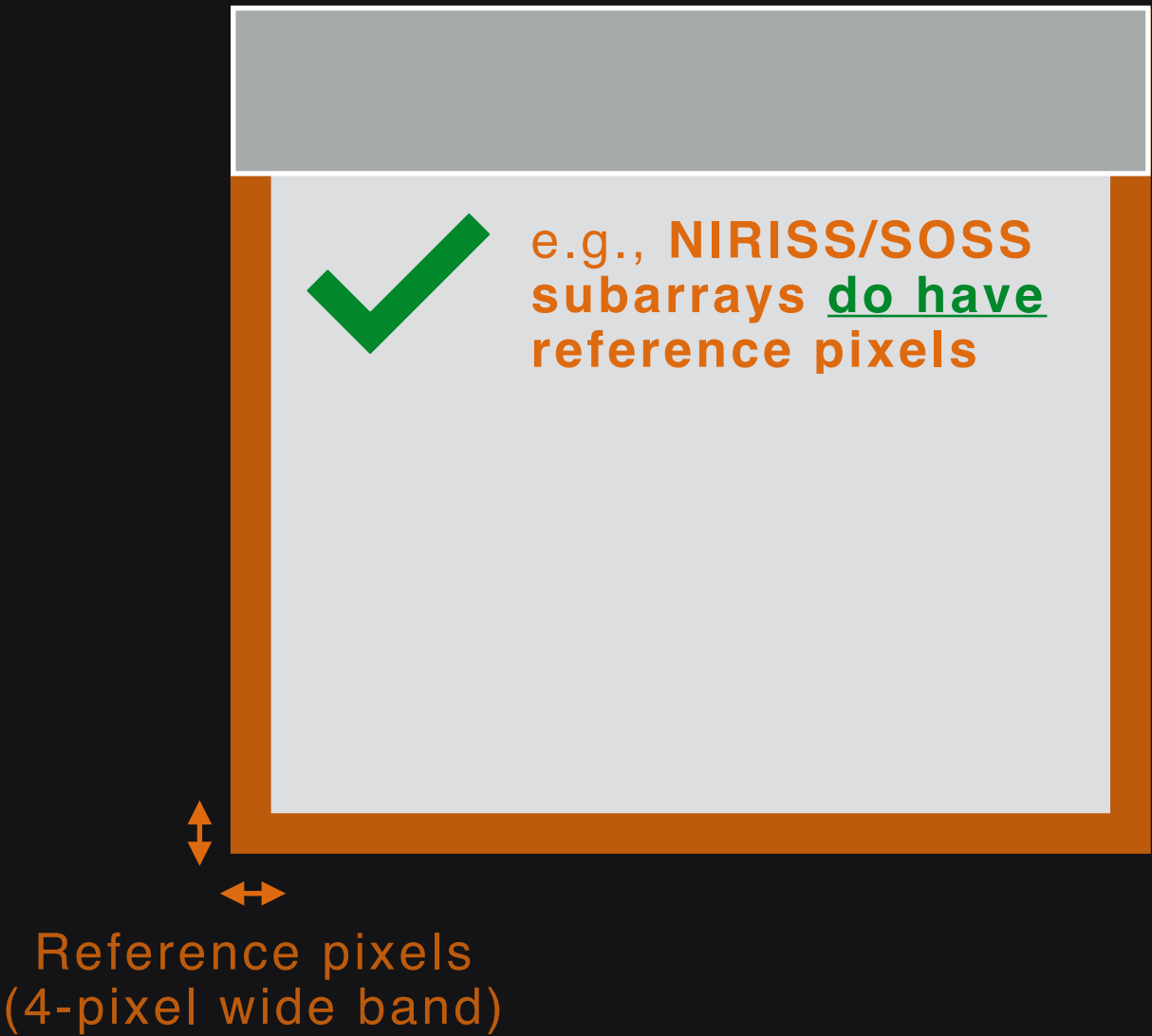
[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

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

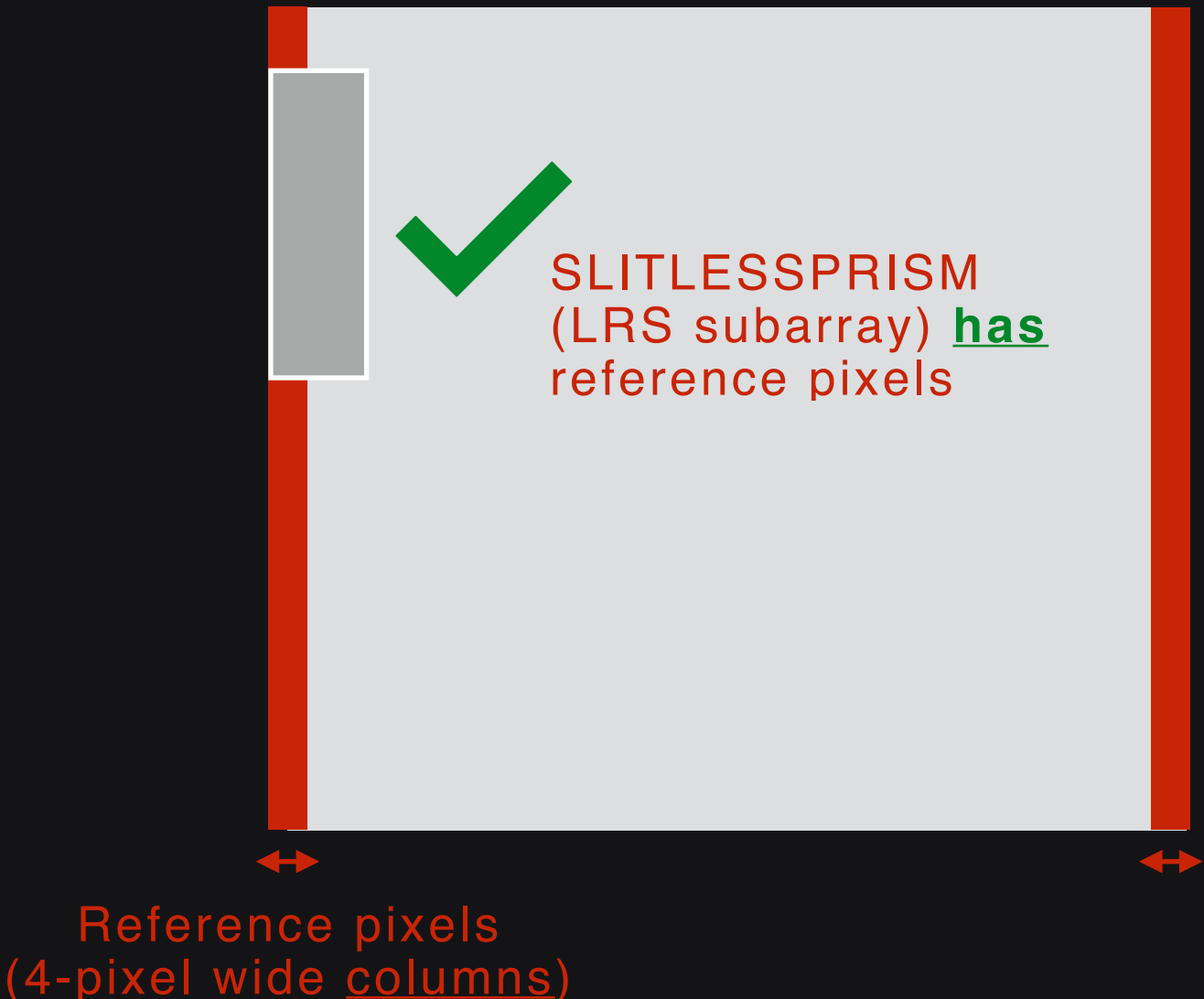
Stage 1 steps

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

(i.e., NIRISS, NIRCам, NIRSpec)  
NIR detectors



(i.e., MIRI)  
IR detectors



# THE JWST DATA REDUCTION PIPELINE

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

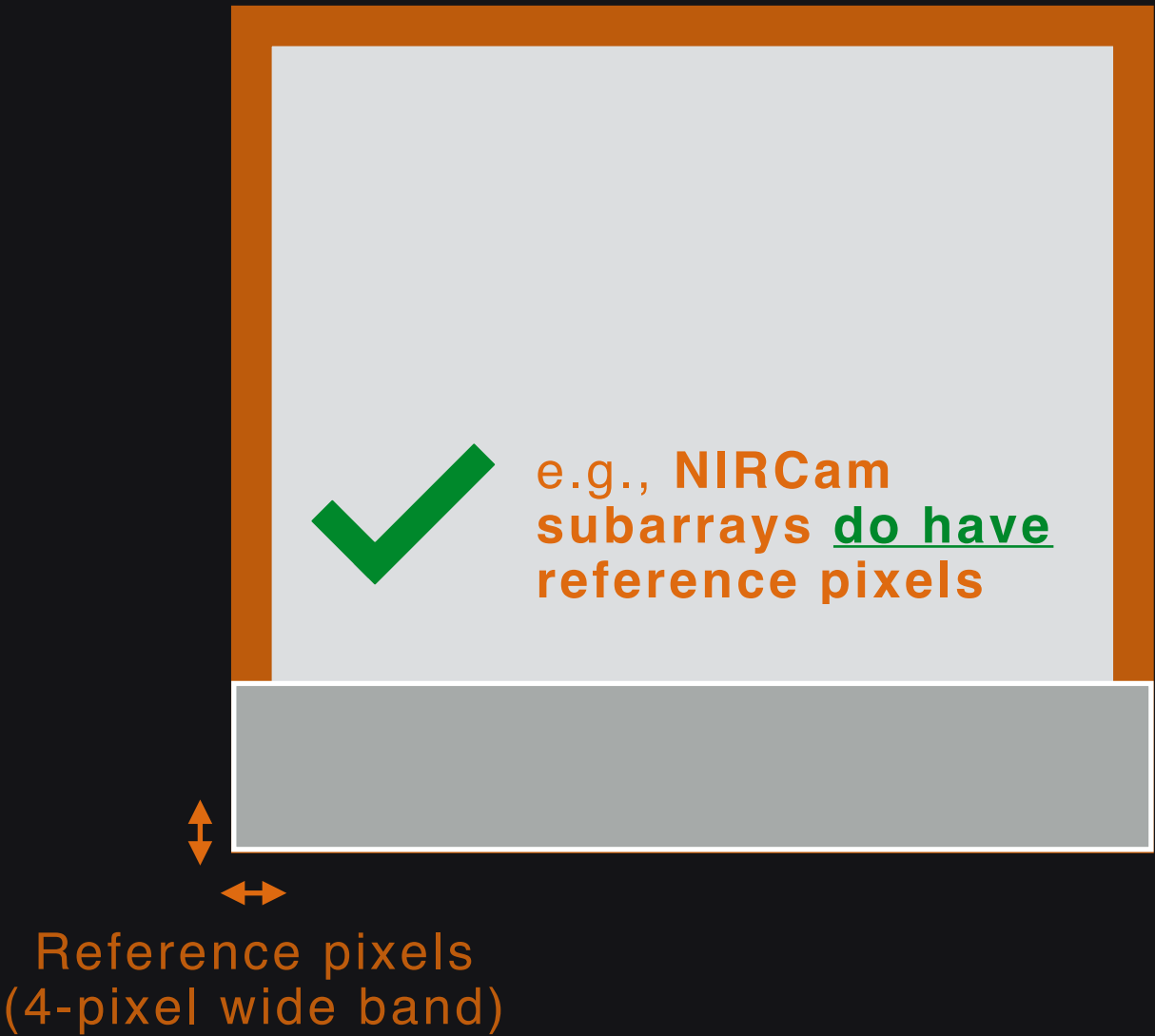
[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

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

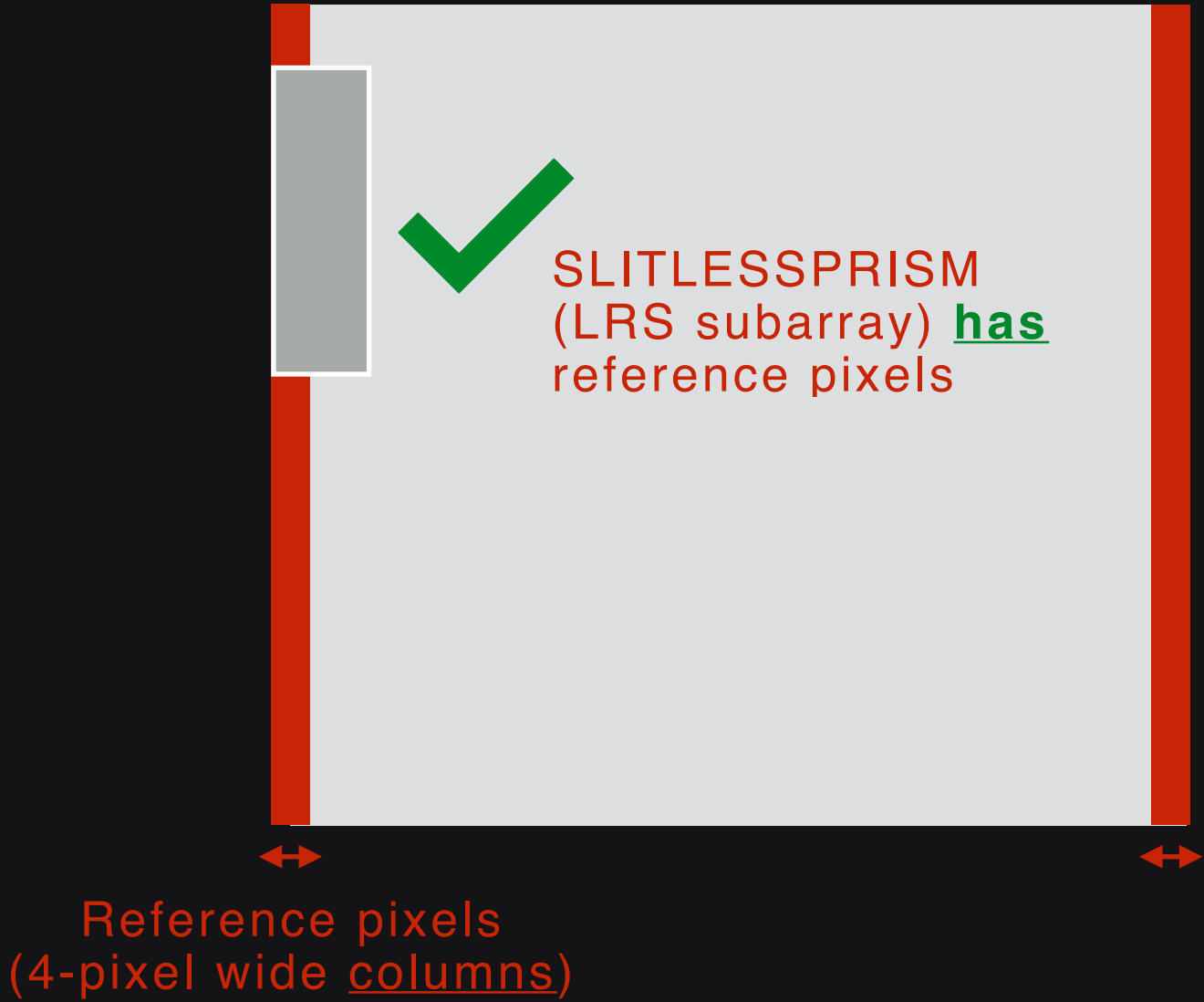
Stage 1 steps

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

(i.e., NIRISS, NIRCам, 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](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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**:

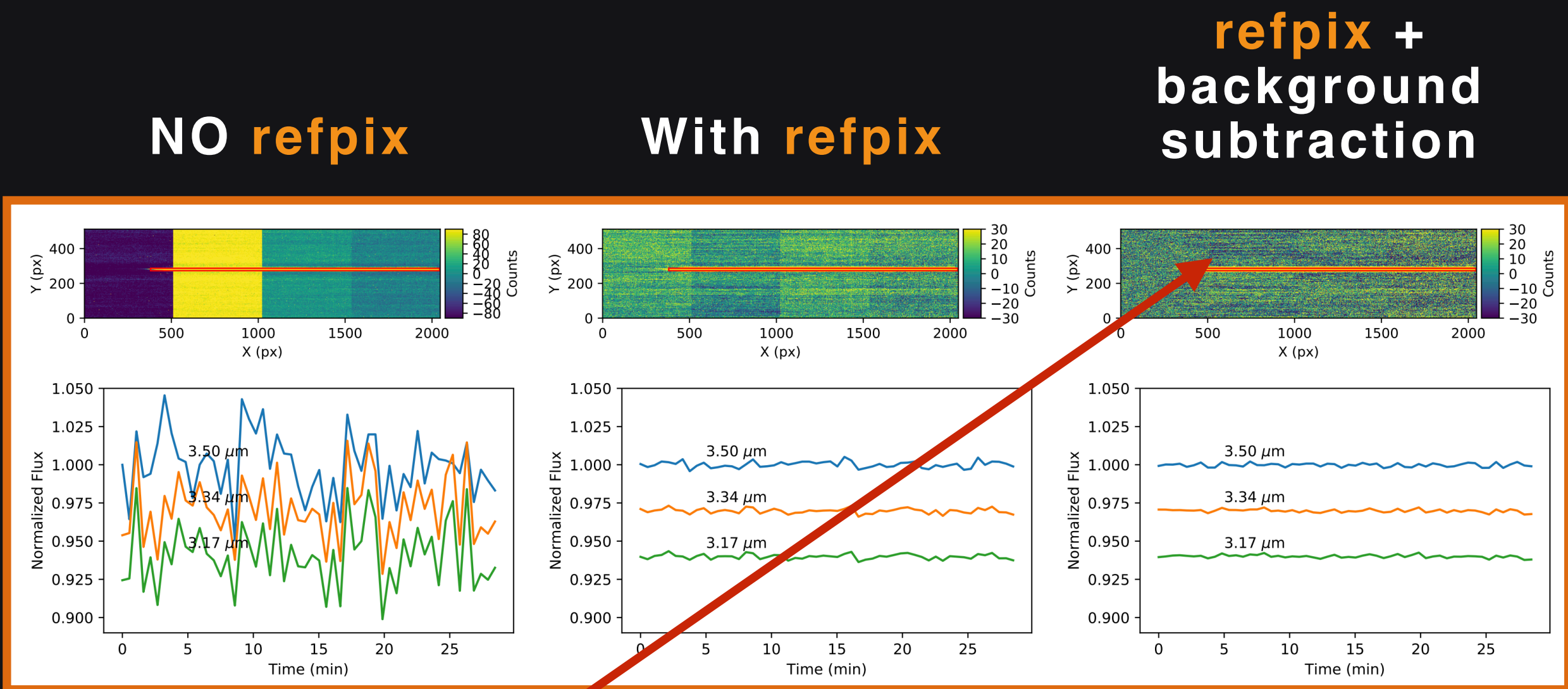


Image credit: Schlawin 2020, AJ, 160, 231

“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

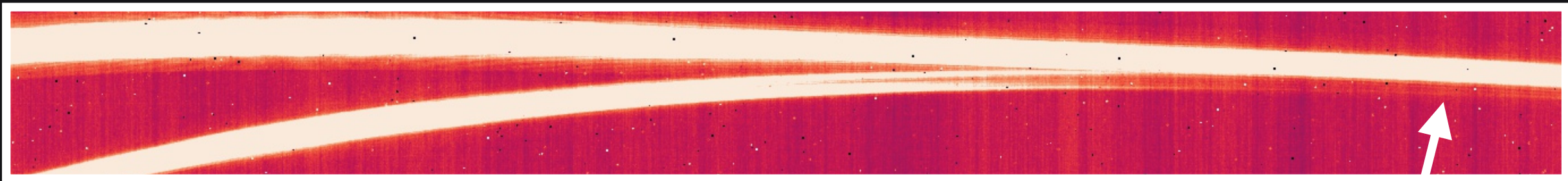
[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

Near-IR			MIRI		
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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

Some detector effects will remain:  
always look at your data!

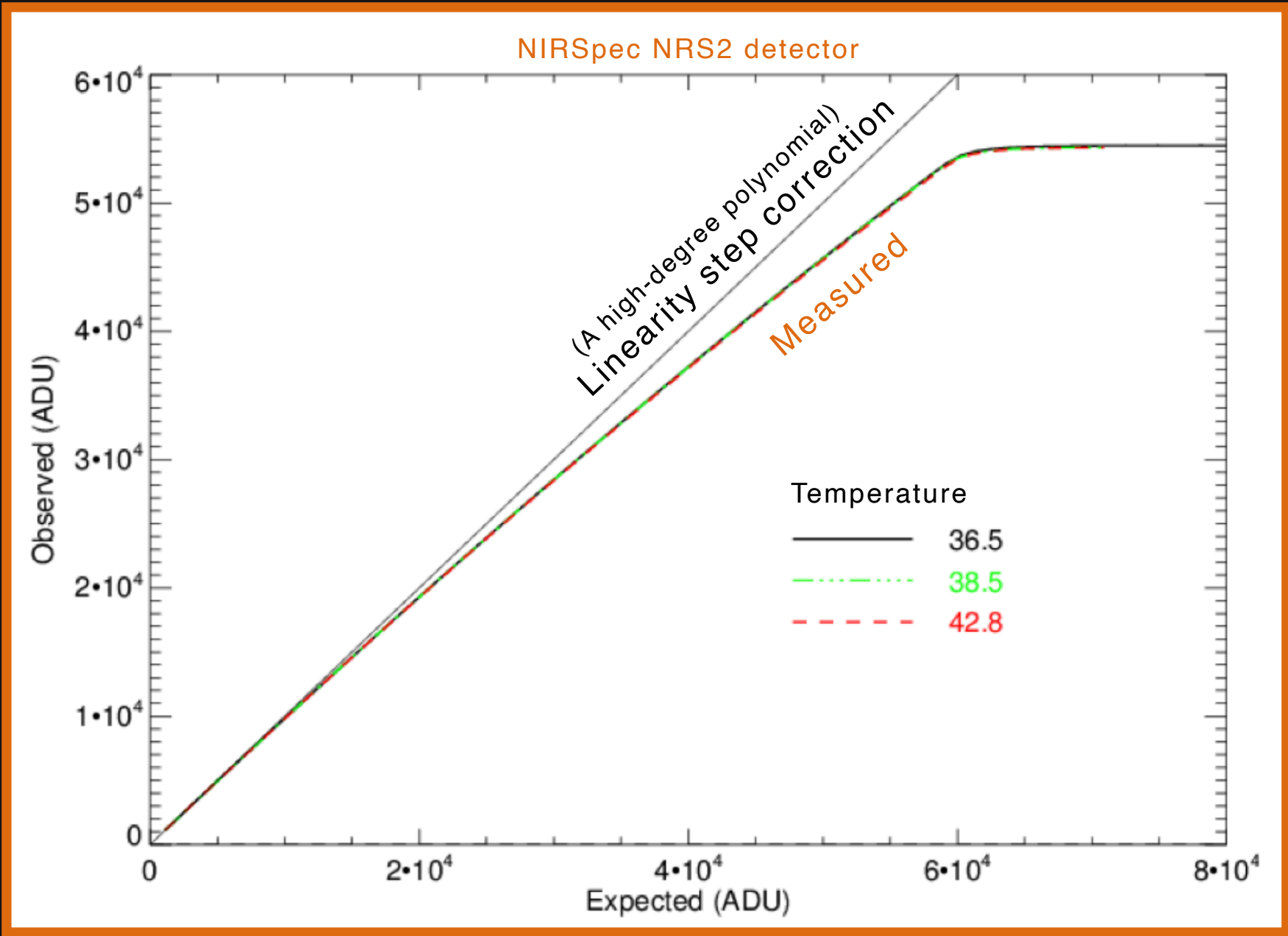
# THE JWST DATA REDUCTION PIPELINE

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

[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

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



Stage 1 steps



# THE JWST DATA REDUCTION PIPELINE

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

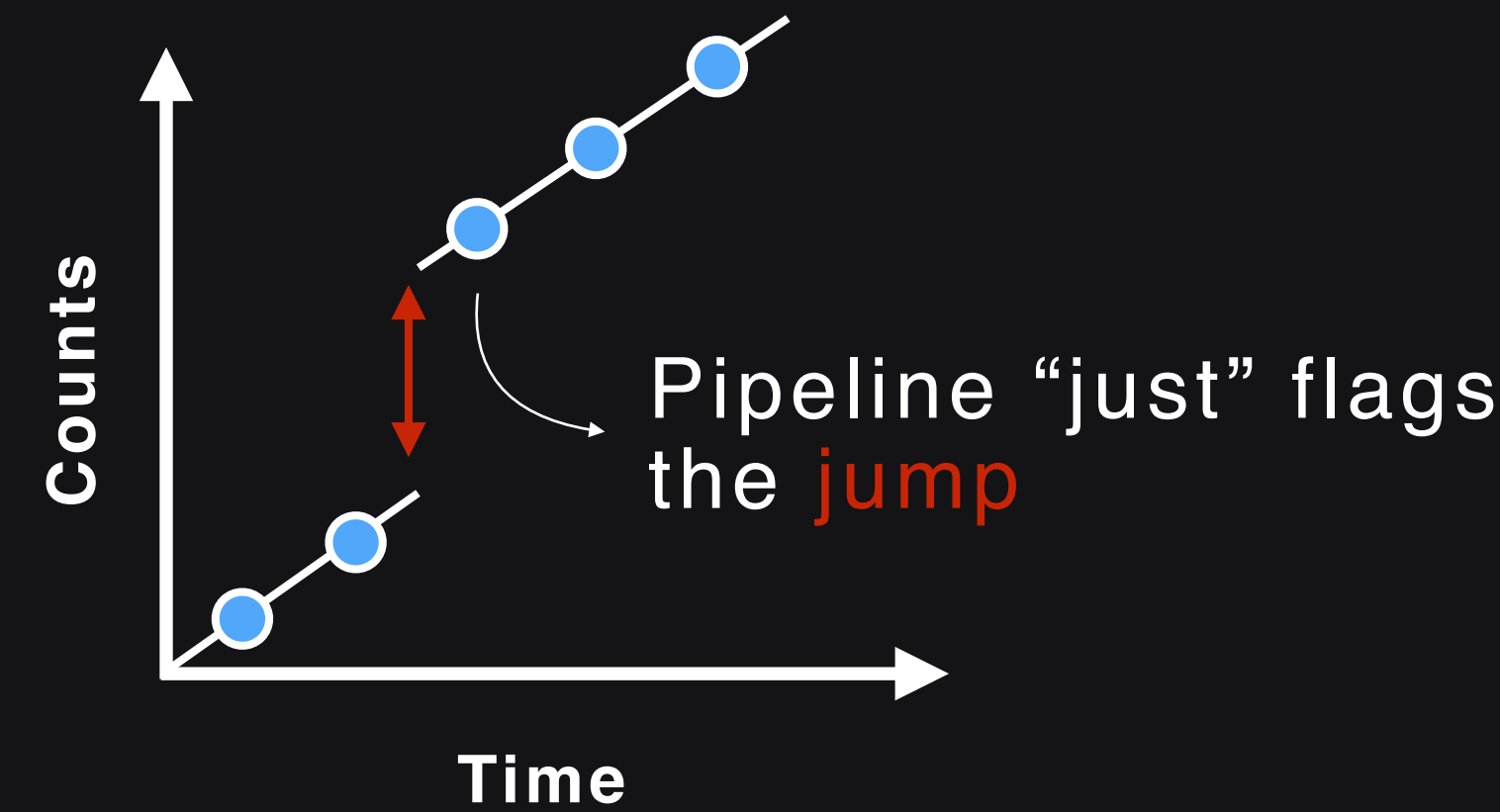
[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_detector1.html)

Near-IR			MIRI		
Step	Non-TSO	TSO	Step	Non-TSO	TSO
group_scale	✓	✓	group_scale	✓	✓
dq_init	✓	✓	dq_init	✓	✓
saturation	✓	✓	saturation	✓	✓
ipc <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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](http://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

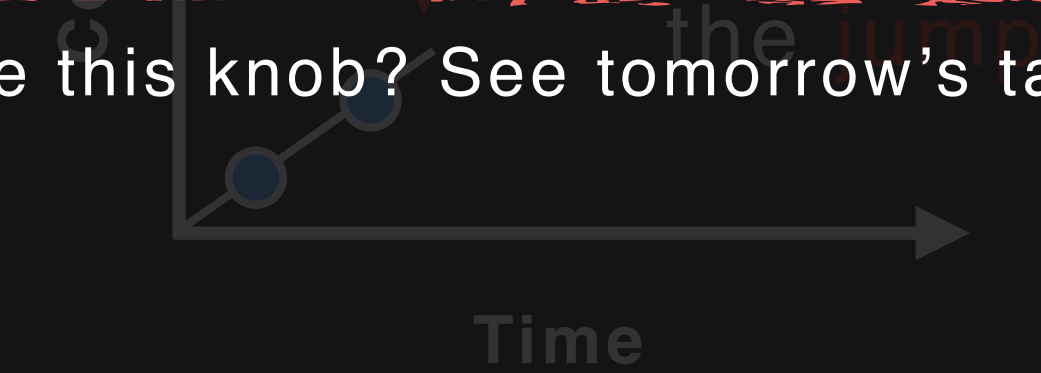
Stage 1 steps

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

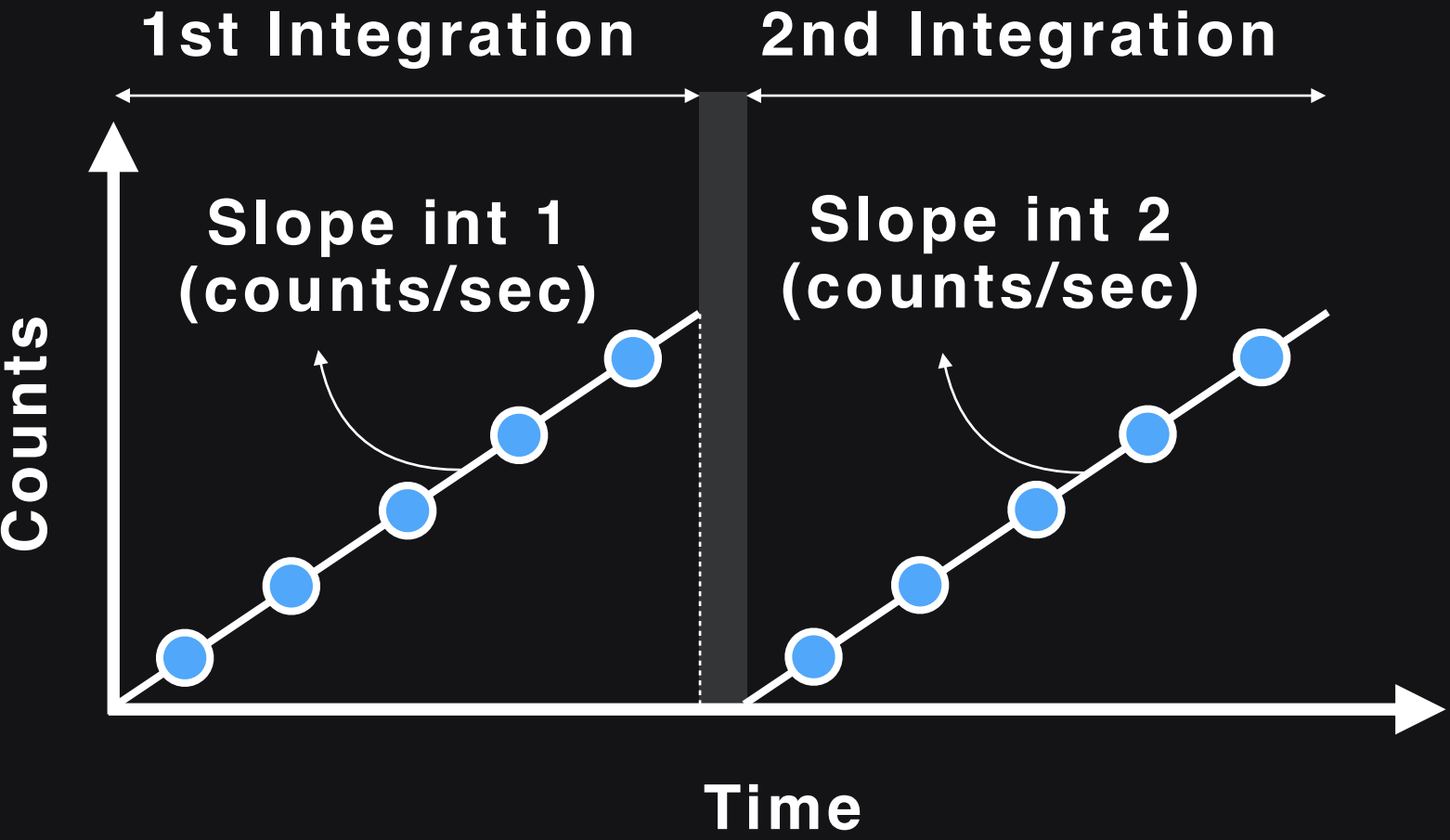
Stage 1 steps, and what to be on the lookout for

[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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

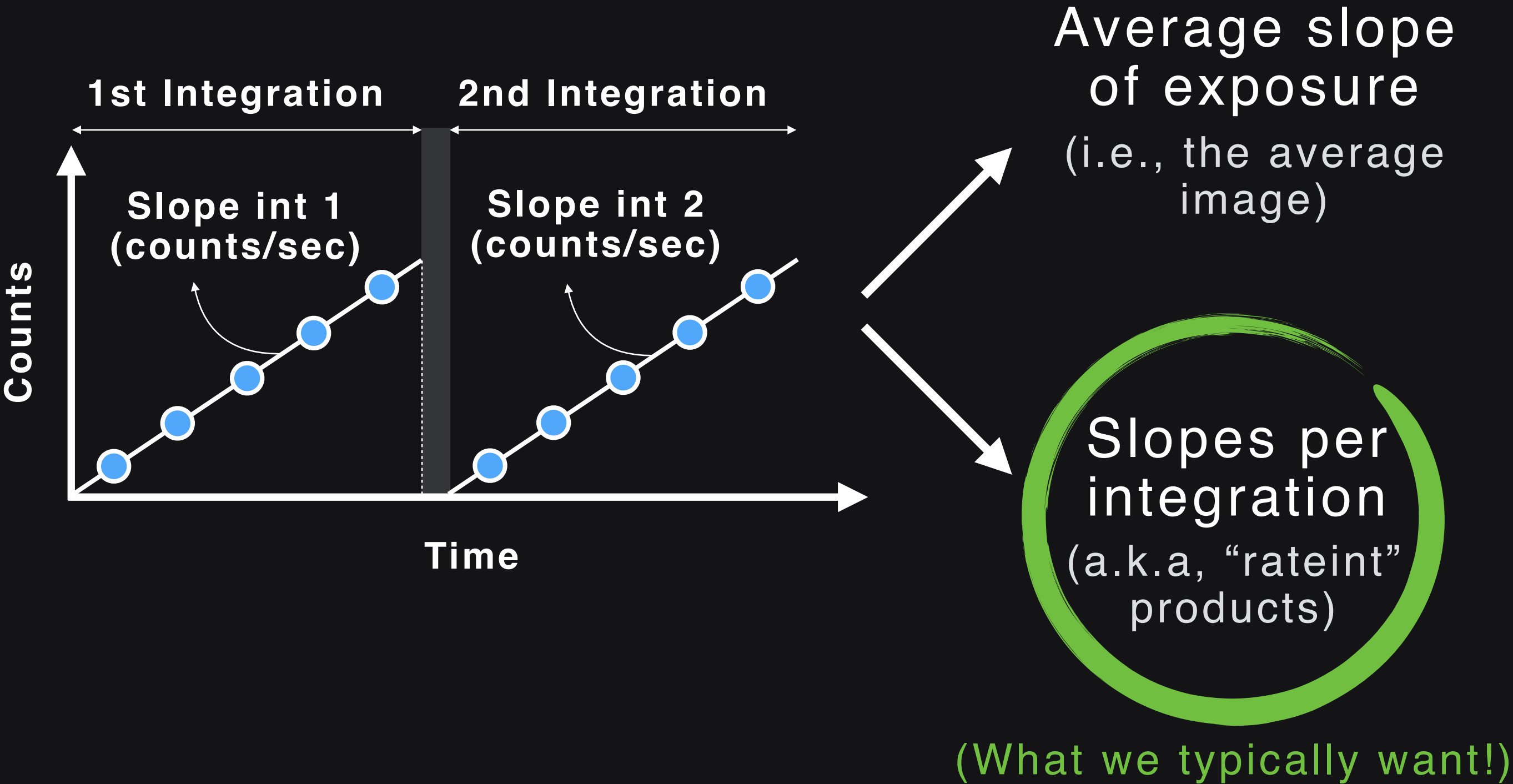
Stage 1 steps, and what to be on the lookout for

[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_detector1.html](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		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](https://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 <sup>1</sup>			ipc		
superbias	✓	✓	firstframe	✓	
refpix	✓	✓	lastframe	✓	
linearity	✓	✓	linearity	✓	✓
persistence <sup>2</sup>	✓		rscd	✓	
dark_current	✓	✓	dark_current	✓	✓
			refpix	✓	✓
jump	✓	✓	jump	✓	✓
ramp_fitting	✓	✓	ramp_fitting	✓	✓
gain_scale	✓	✓	gain_scale	✓	✓

Stage 1 steps

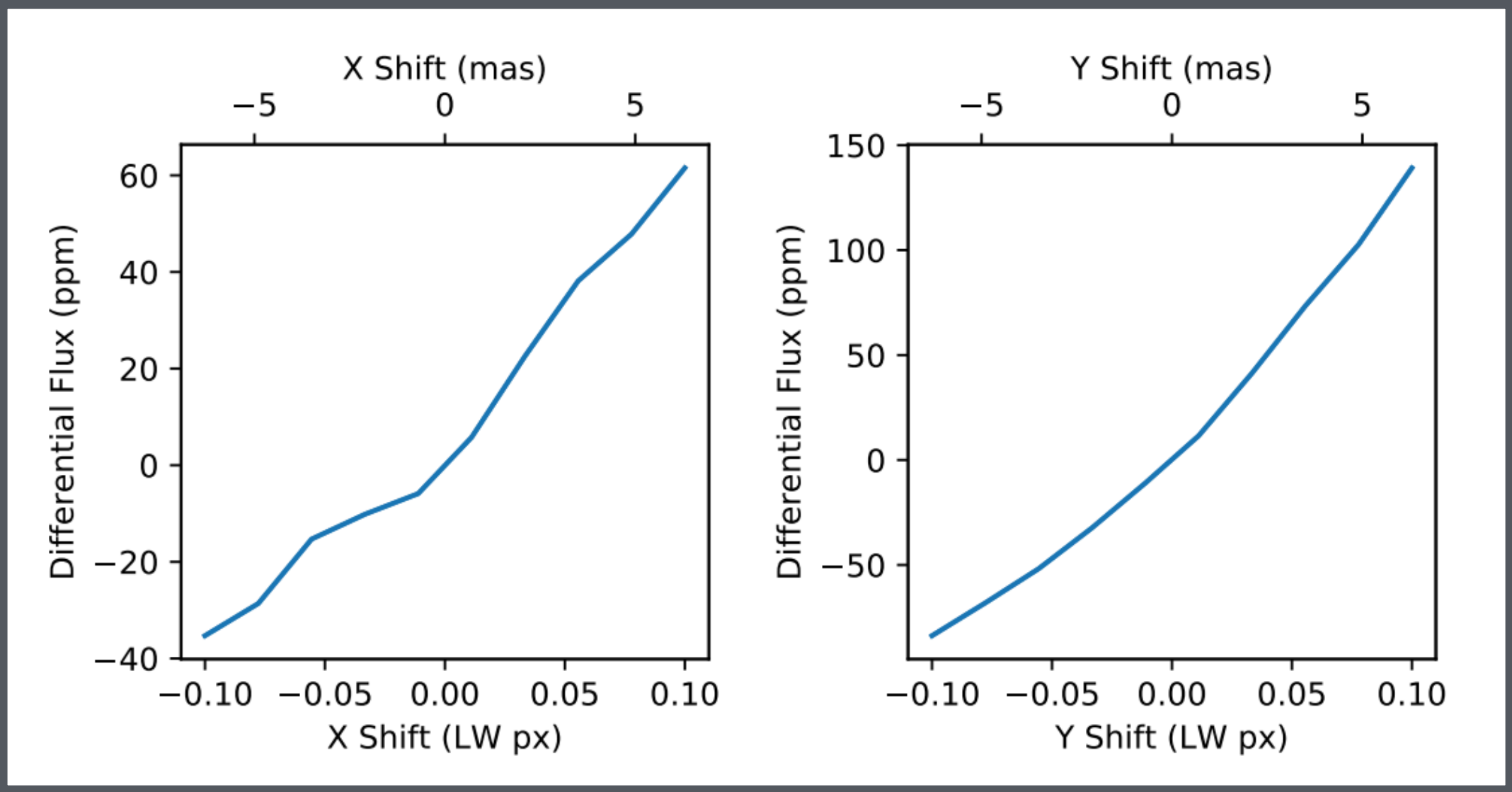
The **ramp\_fitting** step obtains the slope on the up-the-ramp samples:



# 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](https://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
<a href="#">assign_wcs</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">background</a>	✓	✓	✓	✓		✓	✓	✓	✓	
<a href="#">imprint</a>		✓	✓							
<a href="#">msaflagopen</a>		✓	✓							
<a href="#">extract_2d<sup>1</sup></a>	✓	✓						✓	✓	✓
<a href="#">srctype<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓			✓
<a href="#">master_background</a>		✓								
<a href="#">wavecorr</a>	✓	✓								
<a href="#">flat_field<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">straylight</a>						✓				
<a href="#">fringe</a>						✓				
<a href="#">pathloss</a>	✓	✓	✓				✓			
<a href="#">barshadow</a>		✓								
<a href="#">photom</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">resample_spec</a>	✓	✓		✓						
<a href="#">cube_build</a>			✓			✓				
<a href="#">extract_1d</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Stage 2 steps

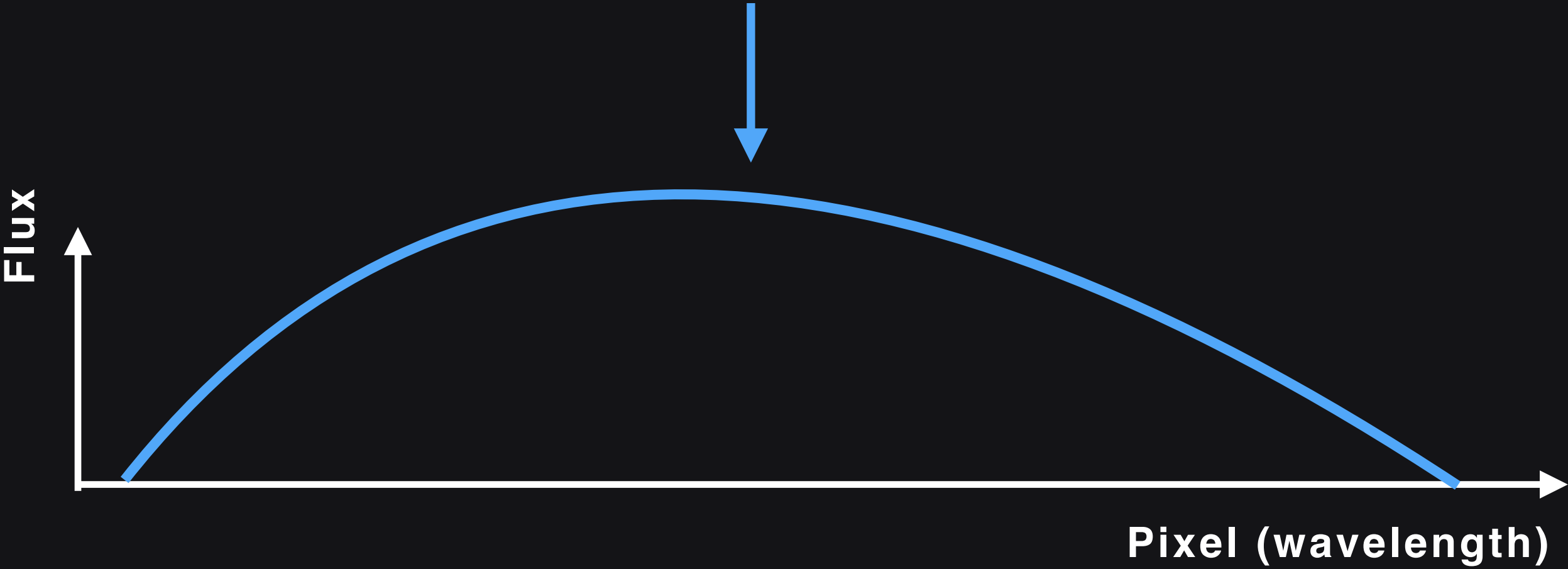


# THE JWST DATA REDUCTION PIPELINE

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](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_spec2.html)

Instrument/Mode	NIRSpec			MIRI			NIRISS		NIRCam	All
	FS	MOS	IFU	FS	SL	MRS	SOSS	WFSS	WFSS	TSO
<a href="#">assign_wcs</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">background</a>	✓	✓	✓	✓		✓	✓	✓	✓	
<a href="#">imprint</a>		✓	✓							
<a href="#">msaflagopen</a>		✓	✓							
<a href="#">extract_2d<sup>1</sup></a>	✓	✓						✓	✓	✓
<a href="#">srctype<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓			✓
<a href="#">master_background</a>		✓								
<a href="#">wavecorr</a>	✓	✓								
<a href="#">flat_field<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">straylight</a>						✓				
<a href="#">fringe</a>						✓				
<a href="#">pathloss</a>	✓	✓	✓				✓			
<a href="#">barshadow</a>		✓								
<a href="#">photom</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">resample_spec</a>	✓	✓		✓						
<a href="#">cube_build</a>			✓			✓				
<a href="#">extract_1d</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

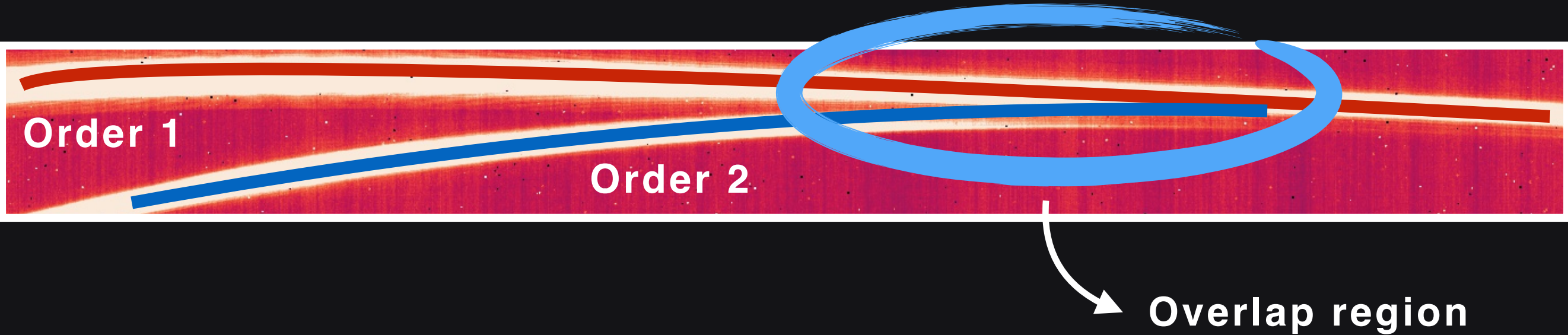
Stage 2 **steps**

# 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](https://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
<a href="#">assign_wcs</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">background</a>	✓	✓	✓	✓		✓	✓	✓	✓	
<a href="#">imprint</a>		✓	✓							
<a href="#">msaflagopen</a>		✓	✓							
<a href="#">extract_2d<sup>1</sup></a>	✓	✓						✓	✓	✓
<a href="#">srctype<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓			✓
<a href="#">master_background</a>		✓								
<a href="#">wavecorr</a>	✓	✓								
<a href="#">flat_field<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">straylight</a>						✓				
<a href="#">fringe</a>						✓				
<a href="#">pathloss</a>	✓	✓	✓				✓			
<a href="#">barshadow</a>		✓								
<a href="#">photom</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">resample_spec</a>	✓	✓		✓						
<a href="#">cube_build</a>			✓			✓				
<a href="#">extract_1d</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

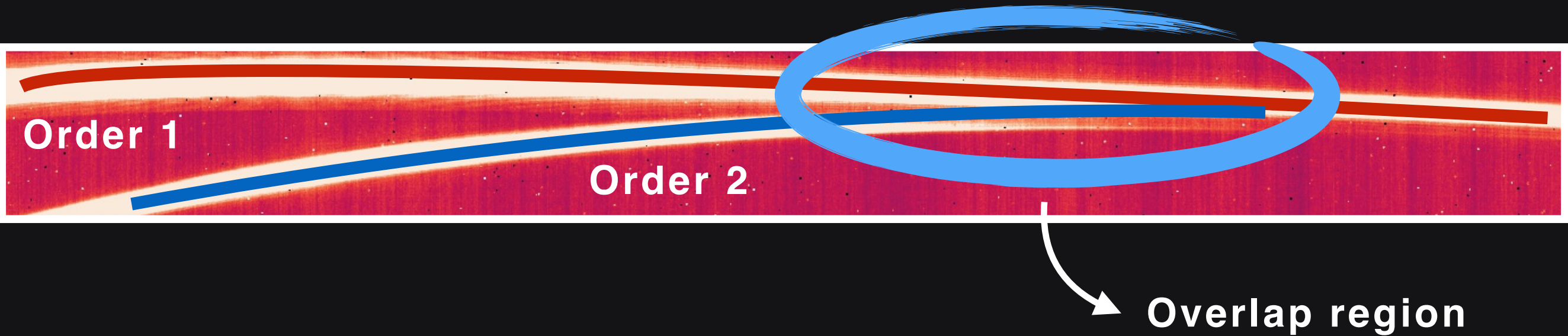
Stage 2 **steps**

# 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!**

[jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb\\_spec2.html](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_spec2.html)

Instrument/Mode	NIRSpec			MIRI			NIRISS		NIRCam	All
	FS	MOS	IFU	FS	SL	MRS	SOSS	WFSS	WFSS	TSO
<a href="#">assign_wcs</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">background</a>	✓	✓	✓	✓		✓	✓	✓	✓	
<a href="#">imprint</a>		✓	✓							
<a href="#">msaflagopen</a>		✓	✓							
<a href="#">extract_2d<sup>1</sup></a>	✓	✓						✓	✓	✓
<a href="#">srctype<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓			✓
<a href="#">master_background</a>		✓								
<a href="#">wavecorr</a>	✓	✓								
<a href="#">flat_field<sup>1</sup></a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">straylight</a>						✓				
<a href="#">fringe</a>						✓				
<a href="#">pathloss</a>	✓	✓	✓				✓			
<a href="#">barshadow</a>		✓								
<a href="#">photom</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<a href="#">resample_spec</a>	✓	✓		✓						
<a href="#">cube_build</a>			✓			✓				
<a href="#">extract_1d</a>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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](https://jwst-pipeline.readthedocs.io/en/latest/jwst/pipeline/calwebb_tso3.html)

calwebb_tso3	Imaging	Spectroscopy
<a href="#">outlier_detection</a>	✓	✓
<a href="#">tso_photometry</a>	✓	
<a href="#">extract_1d</a>		✓
<a href="#">white_light</a>		✓

Currently testing/validating **outlier\_detection** and **white\_light steps**.

Stage 3 **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.