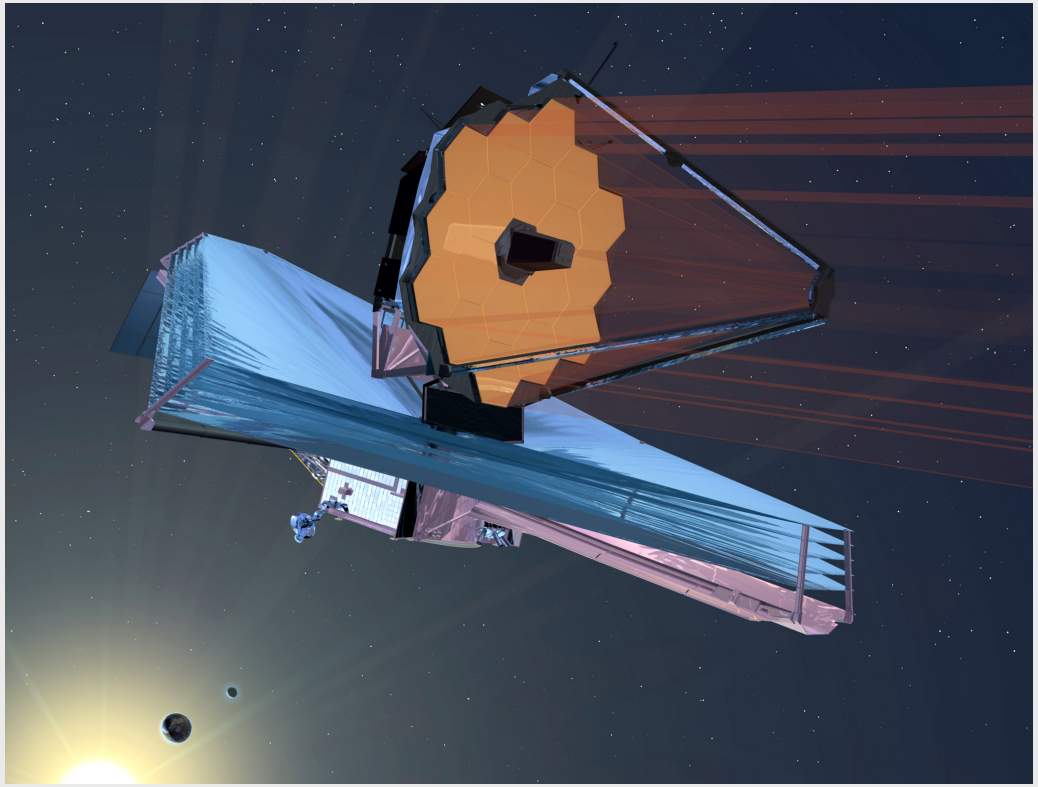
The NIRSpec Data Calibration Pipeline



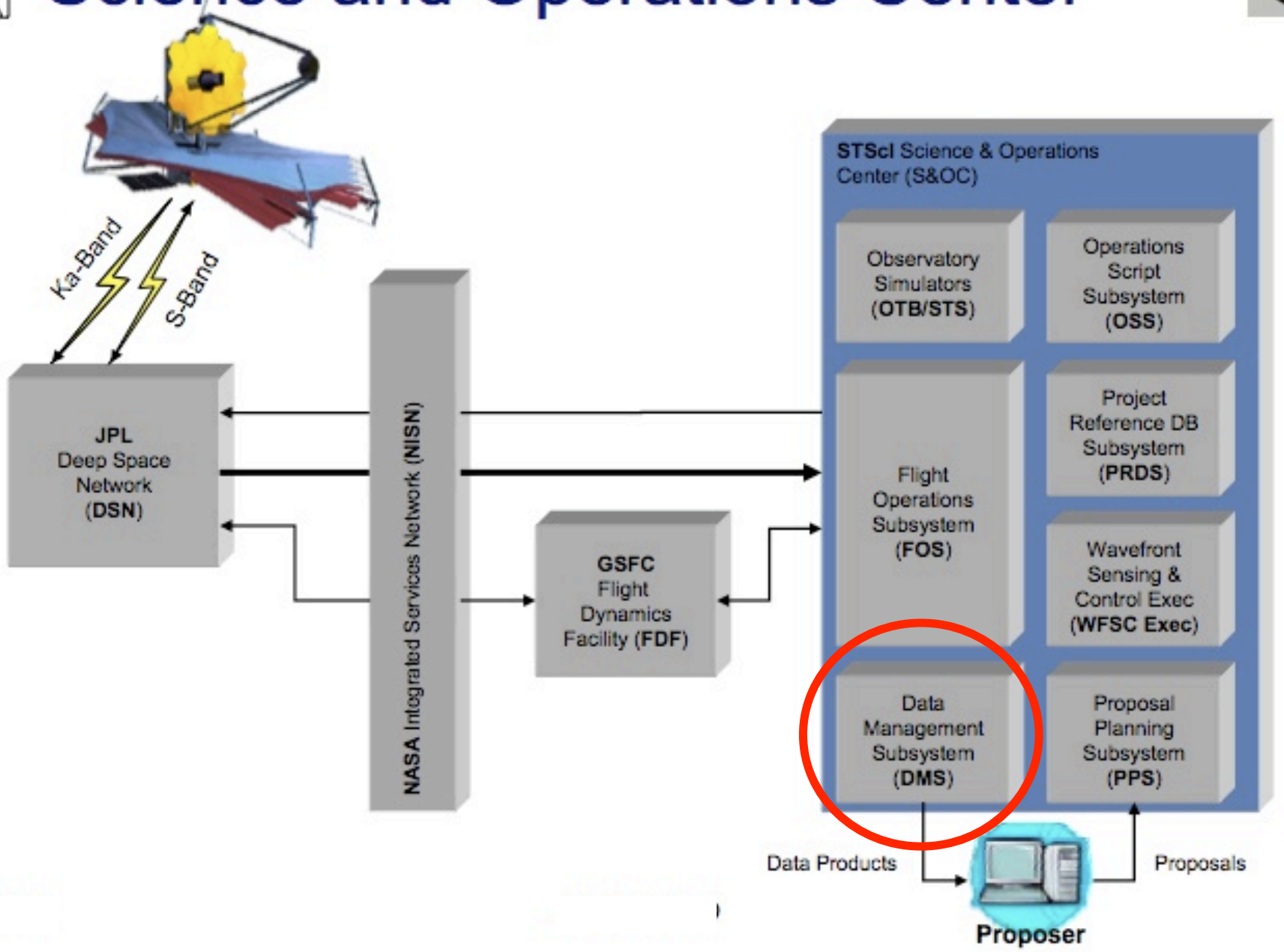
Tracy Beck

Space Telescope Science Institute

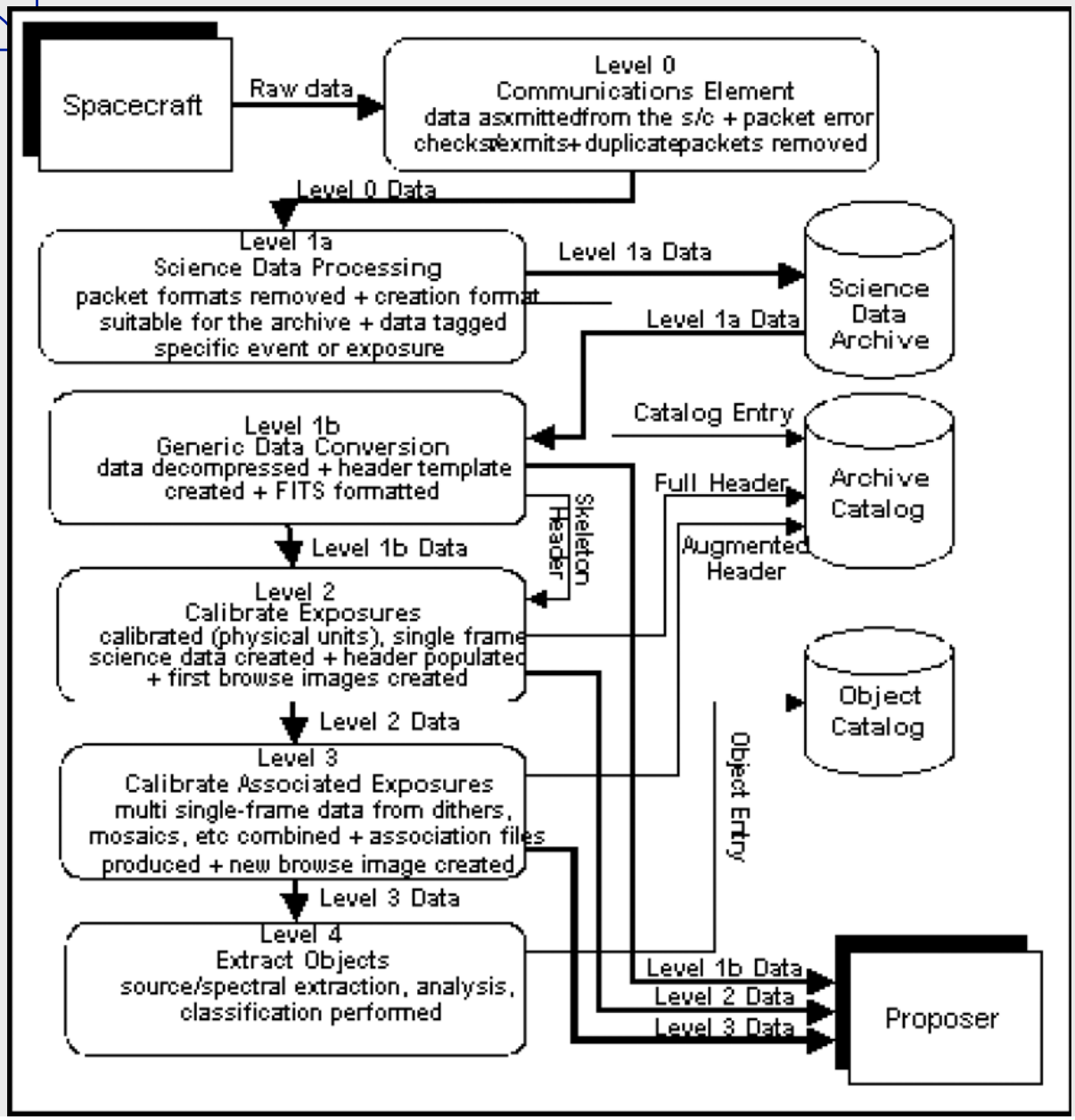
STScI - Science and Operations Center for JWST

Based in Balitmore, MD - STScI is presently the main science center for the Hubble Space Telescope, future science and operations center for JWST

Science and Operations Center



JWST Data Management



Level 0 - Communication from spacecraft

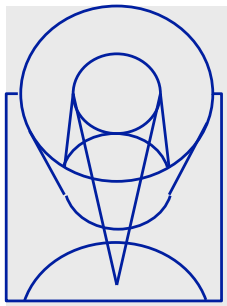
Level 1 - Conversion to raw .fits files

Level 2 - removing telescope/instrument effects, Calibrating data

Level 3 - Combining dithers and associated data

Level 4 - Creating catalogs, extracting spectra, classification

"Calibration"
"Processing"
"Reduction"



The Purpose of Data Processing

Perfectly Calibrated data is what would have been received if an ideal JWST with ideal instruments and ideal detectors had observed the chosen field in the chosen observing mode.

Goal - Remove all Instrument and telescope effects from data!

Using calibrated data, it is possible to:

- Determine the flux incident on each pixel, along with its uncertainty (relative and absolute flux determinations limited by different effects)
- Determine the relative locations and wavelengths of each pixel to very high accuracy (limited by knowledge of the geometric distortions in the telescope + instruments)
- Determine the absolute locations of the observed field to high accuracy (limited by absolute Guide Star / instrument accuracies)
- Do Science!

STScI Calibration Pipeline Philosophy & Archive

Proposer

NASA

JWST

STScI - Data Management System
- .fits file structure, engineering data, Calibration Pipeline Reduction, best data reduction possible

Calibrated data Delivered within 5 days

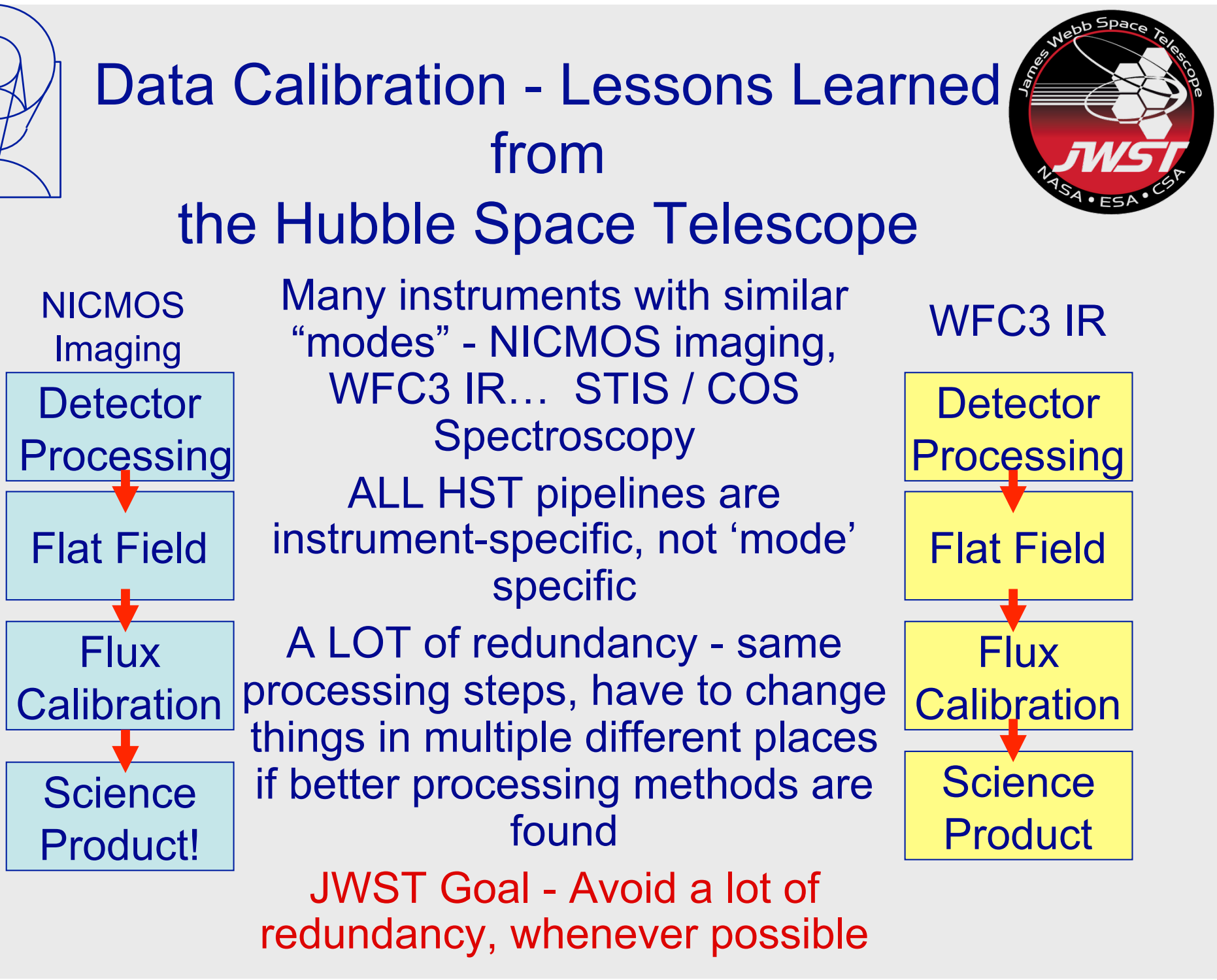
Raw data Delivered within 3 hours

STScI Data Archive

1.5 years

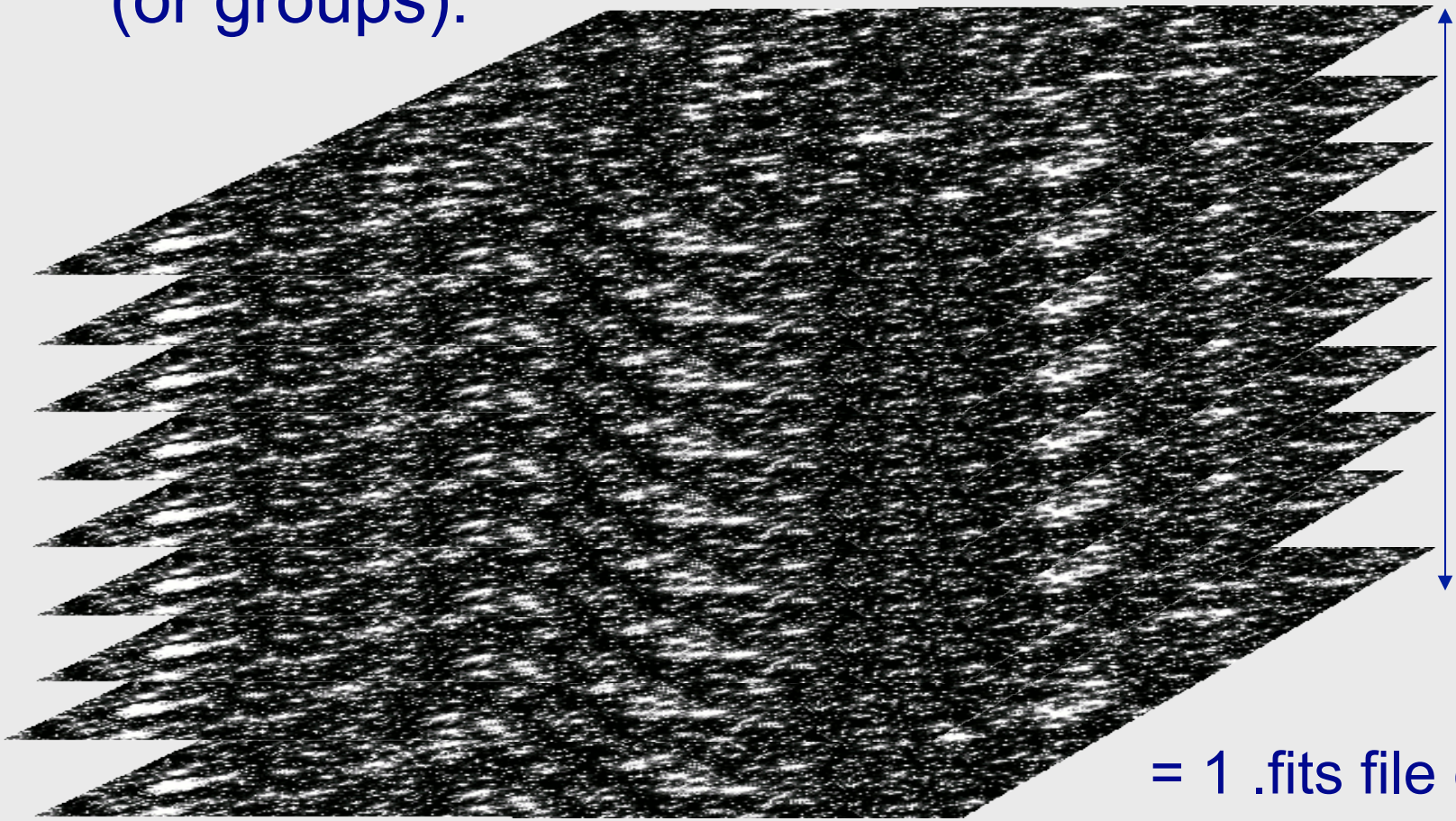
Archive User

Data Calibration - Lessons Learned from the Hubble Space Telescope



NIRSpec Raw Data Format

An exposure is made up of a sequence of frames (or groups):

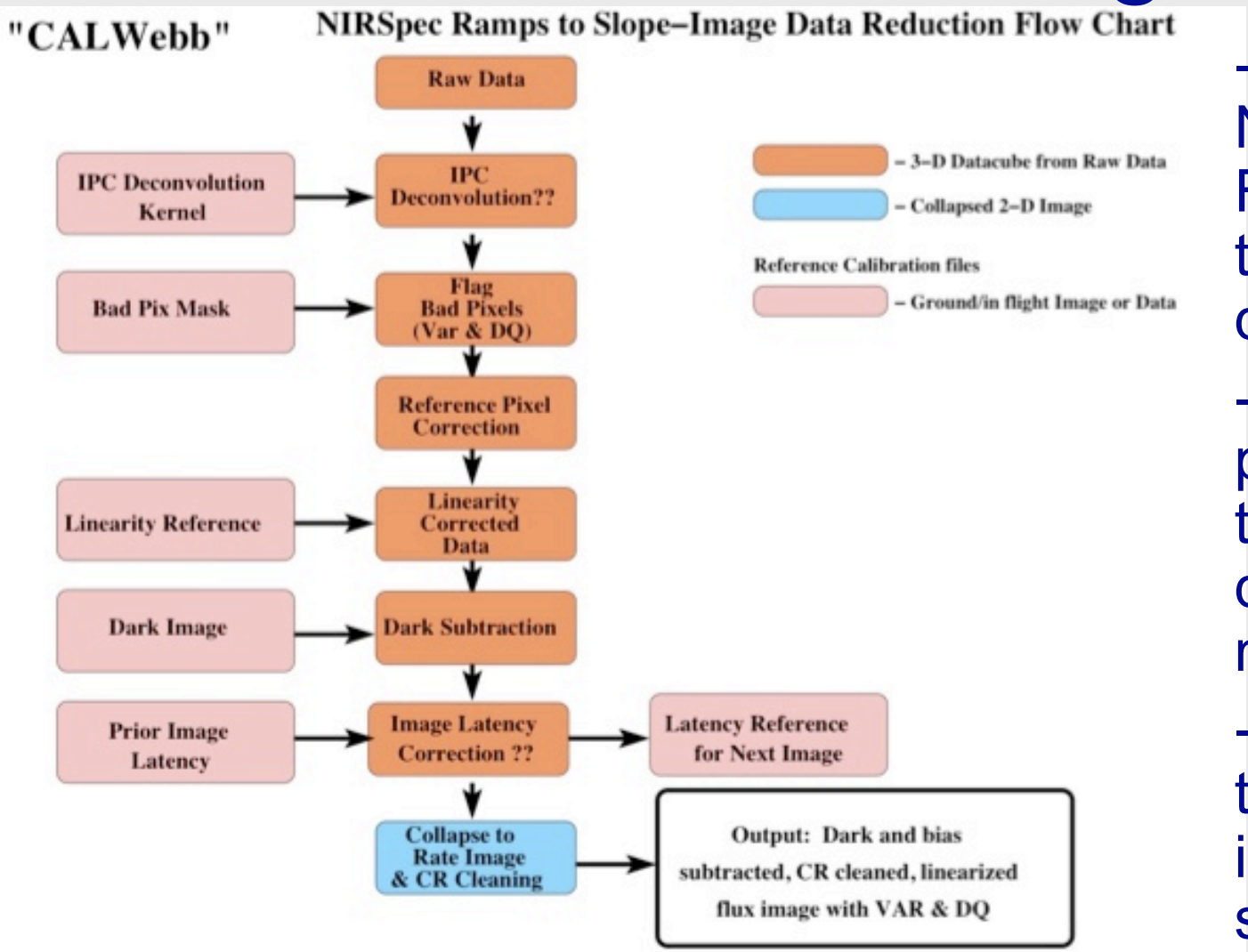


Instead of just an image, get a 3-D datacube, with many exposures - one every 10.6 (or 42) seconds

“Ramps”

= 1 .fits file exposure

Common Instrument Detector Processing Steps

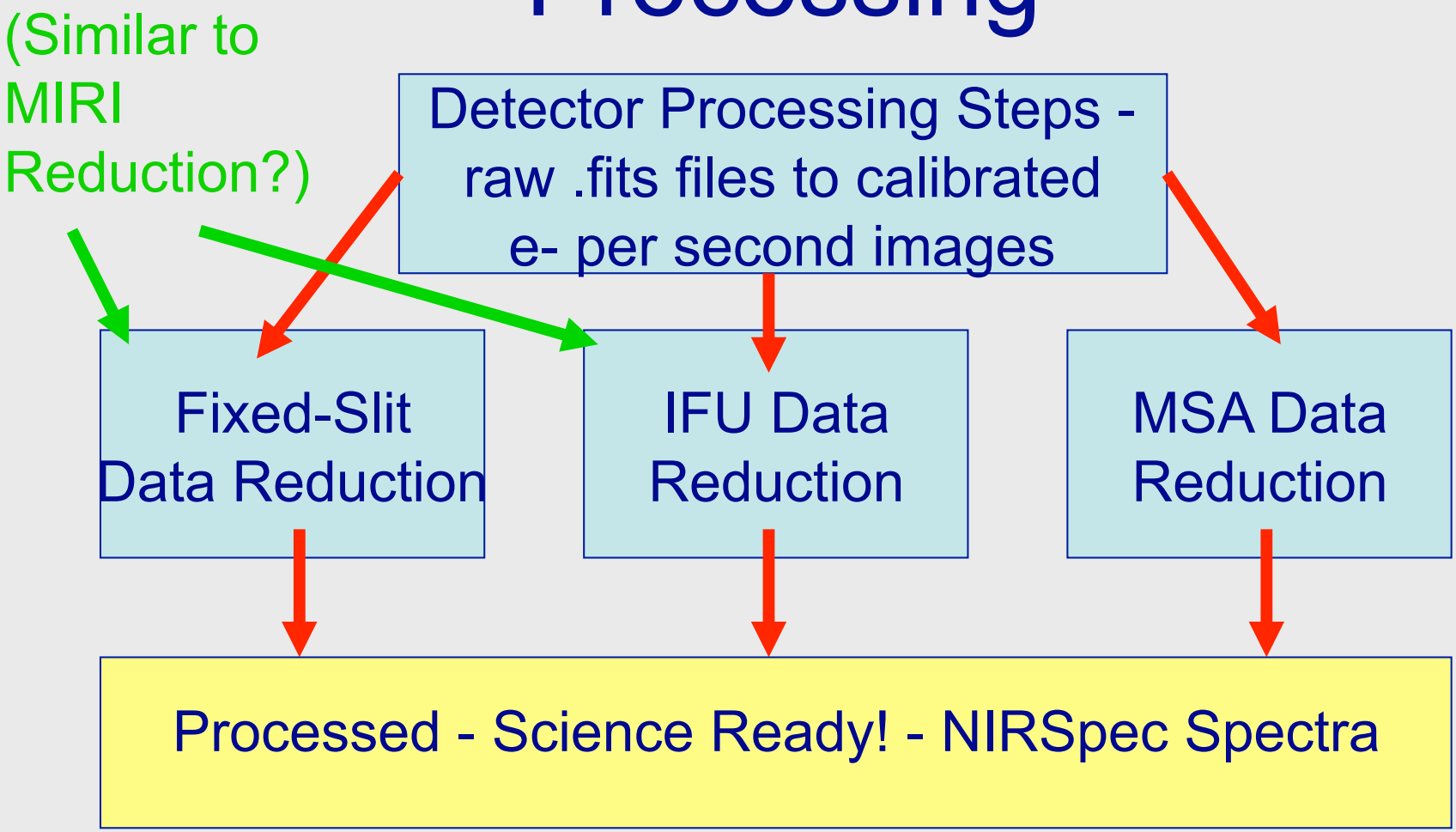


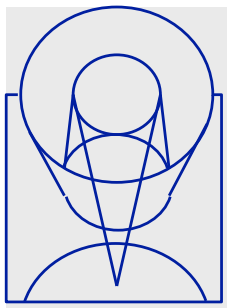
- NIRSpec, NIRCam and FGS/TFI all have the same kind of detectors

-Initial processing steps to remove detector effects may be identical

-3D Datacubes to calibrated 2D images of e^- per second

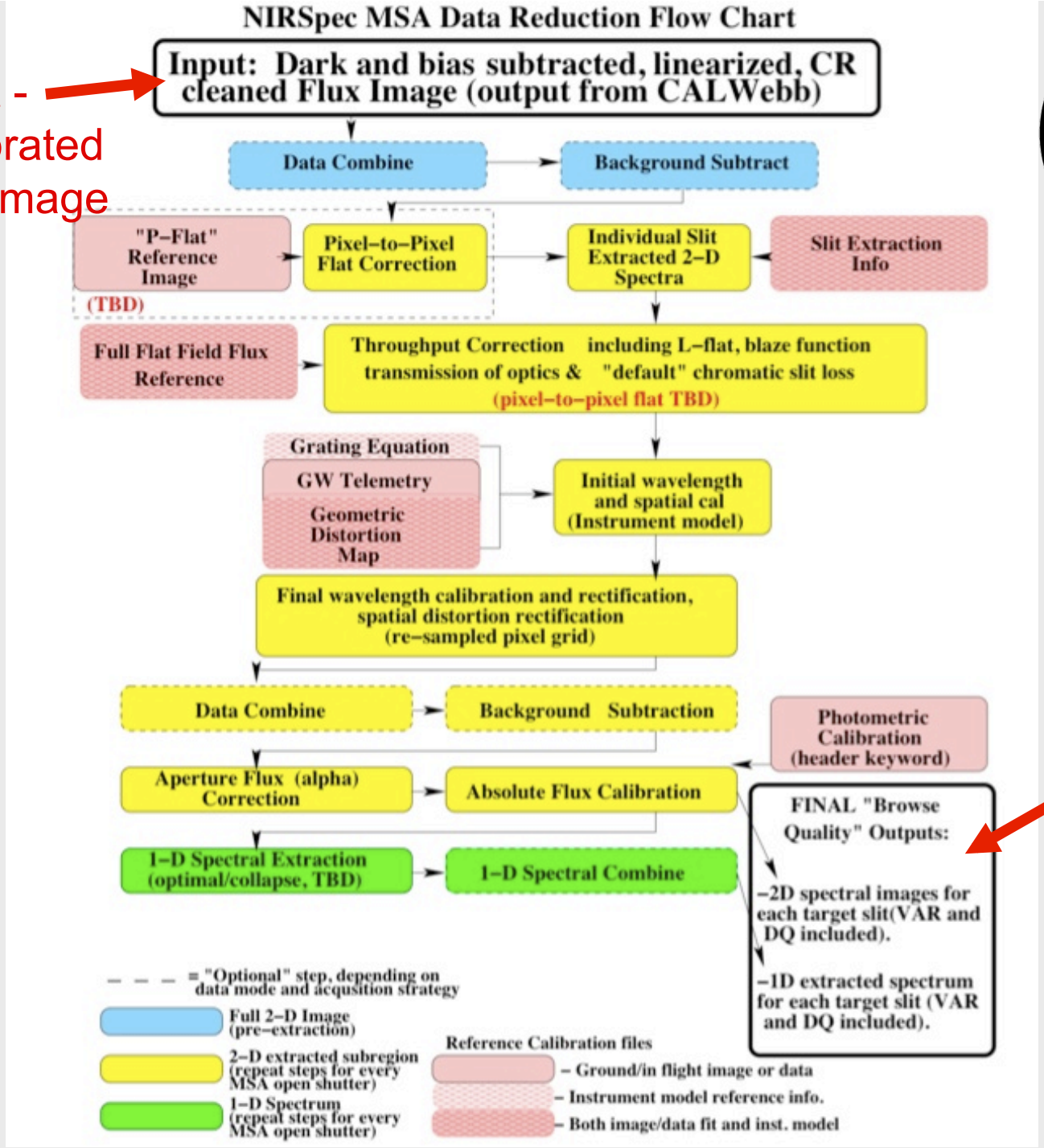
NIRSpec Data Pipeline Processing





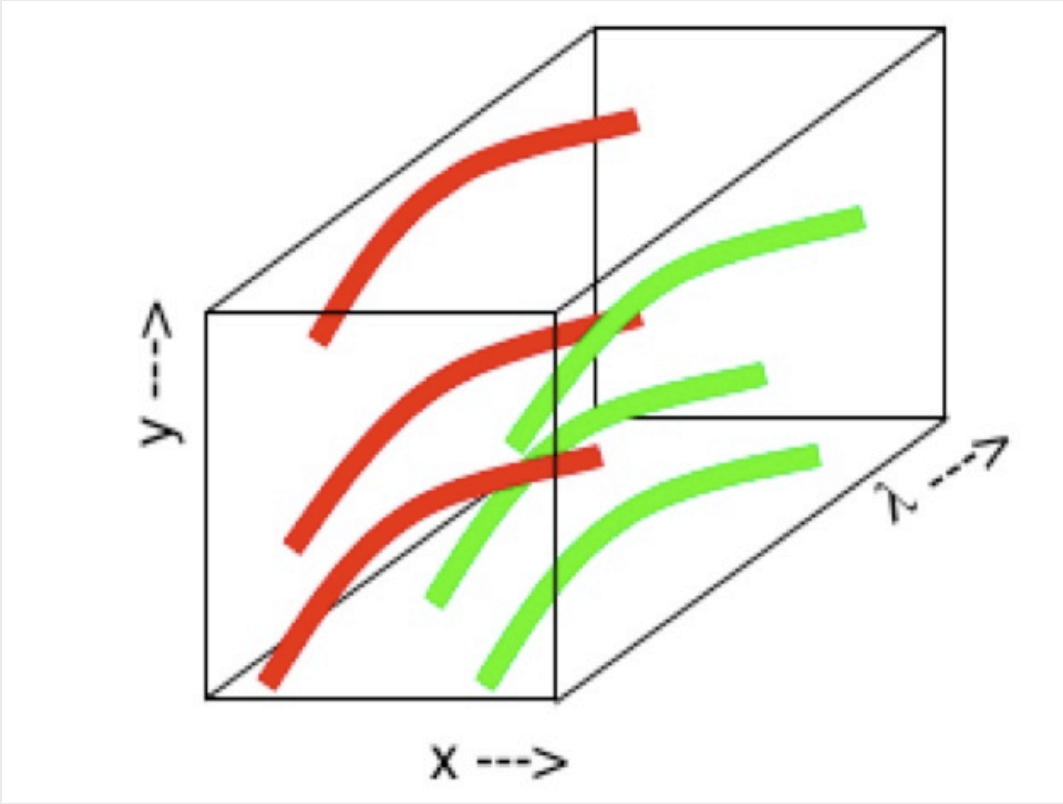
Input - Calibrated 2-D Image

NIRSpec MSA Data Reduction



Output - Calibrated 2-D and 1-D Spectra of each MSA shutter

Calibration of NIRSpec Data



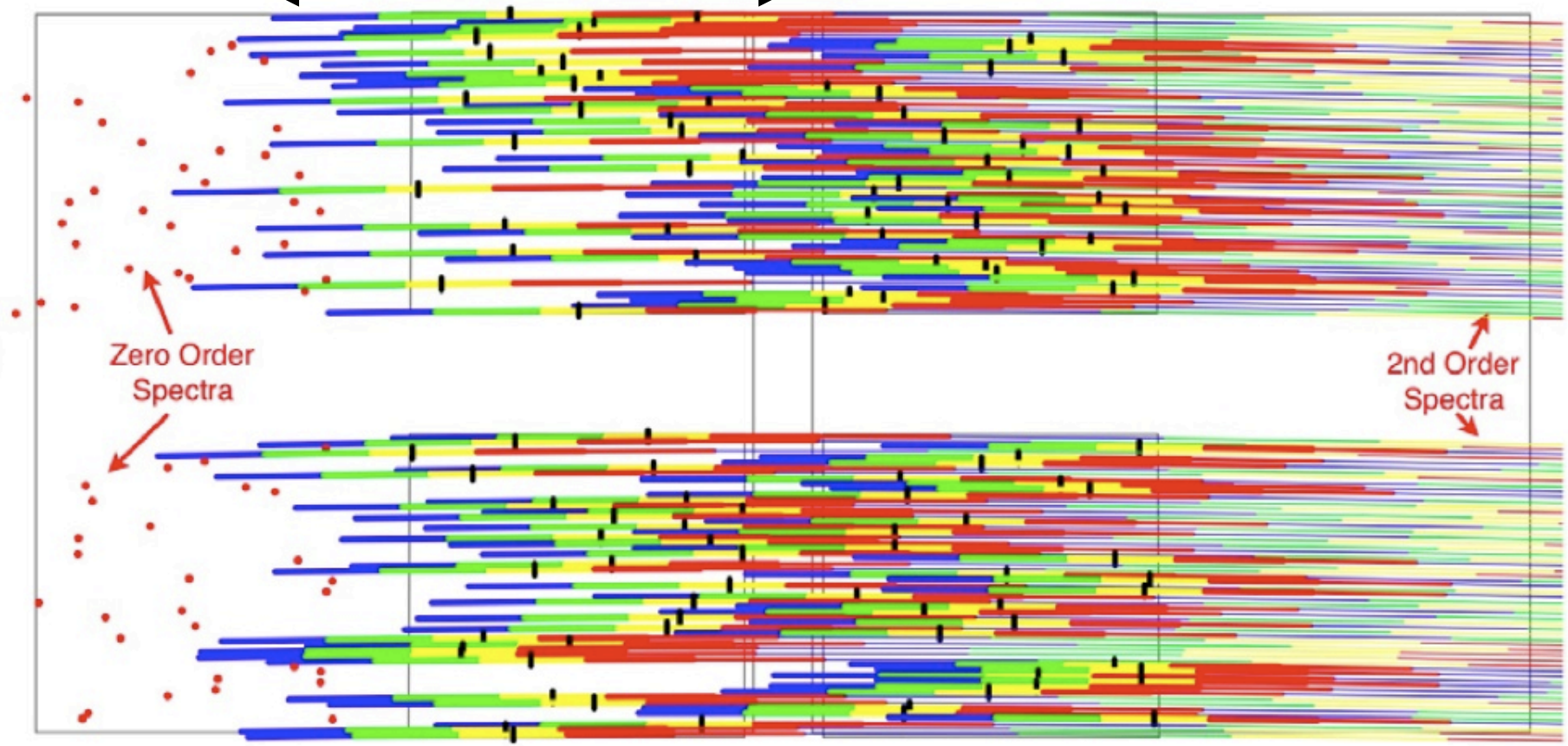
Spectra for one MSA quadrant - Each MSA shutter has an associated throughput model spectrum

For efficiency, we plan to use a NIRSpec throughput and flat field model, rather than telescope images to correct for instrument illumination effects.

Simulated MSA Data

1st Order (Primary data)

R=1000 Spectra

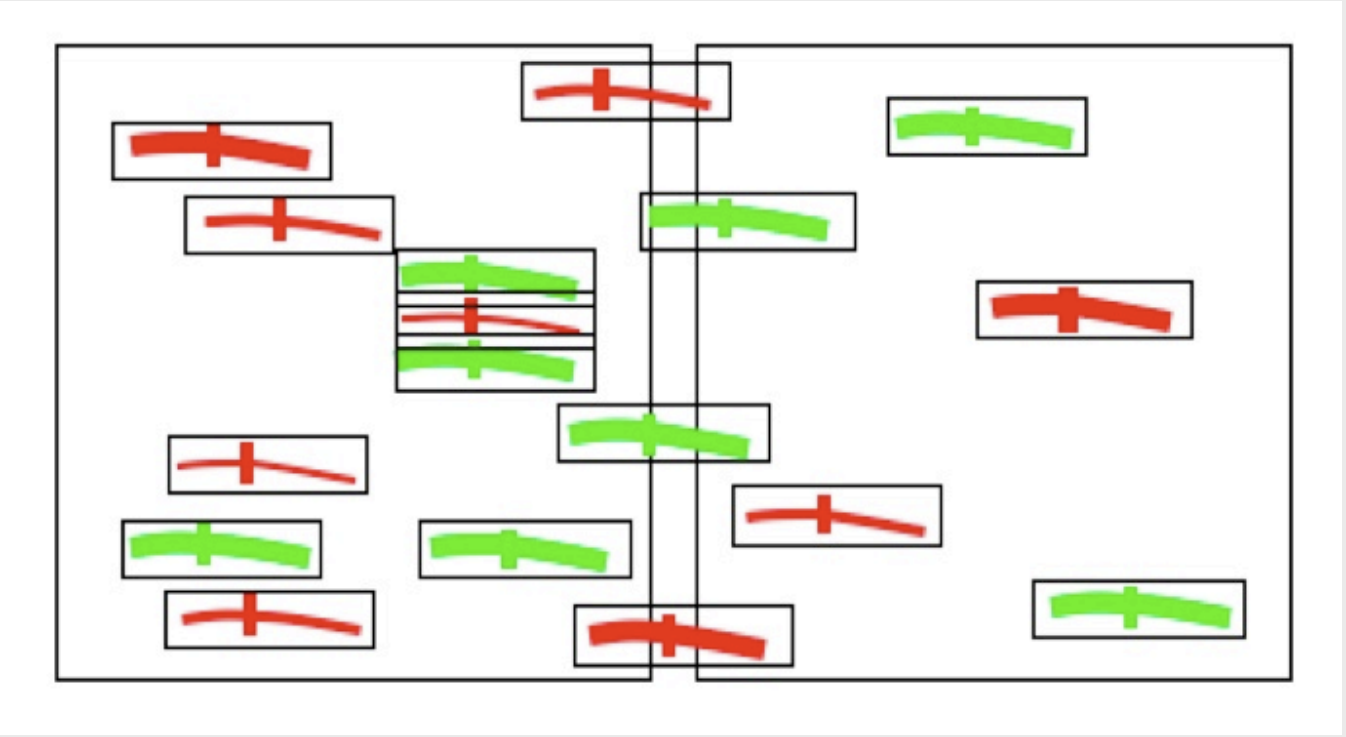


~100+ Targets observed simultaneously + background shutters!

Calibration of NIRSpec Data

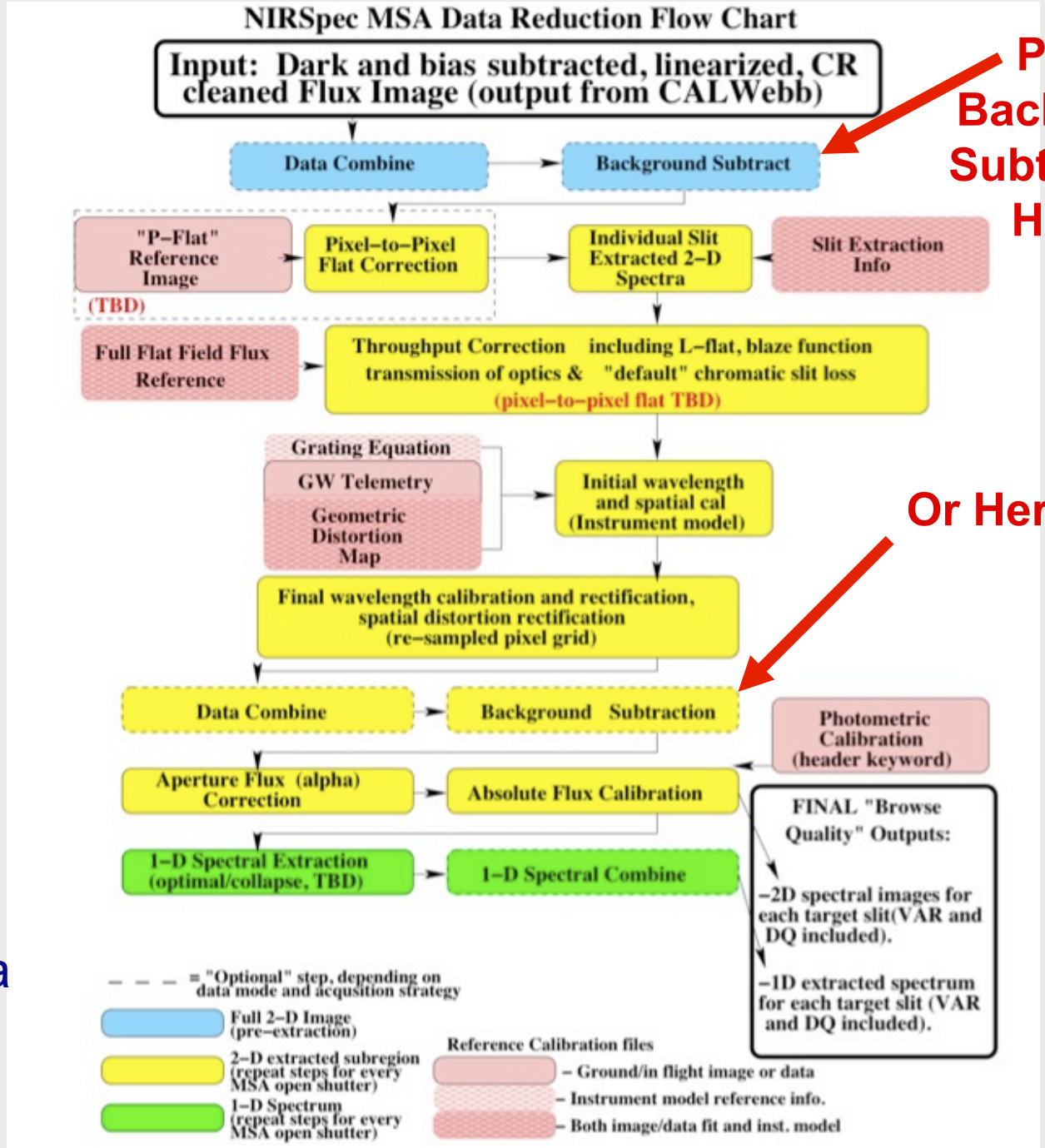
Red = Science Target

Green = Background



Must remove background flux from science targets. How do we know which shutter has which target in it? & Which is Background? (done in the Planning Tool - info. propagated to the pipeline reduction)

Calibration of NIRSpec Data

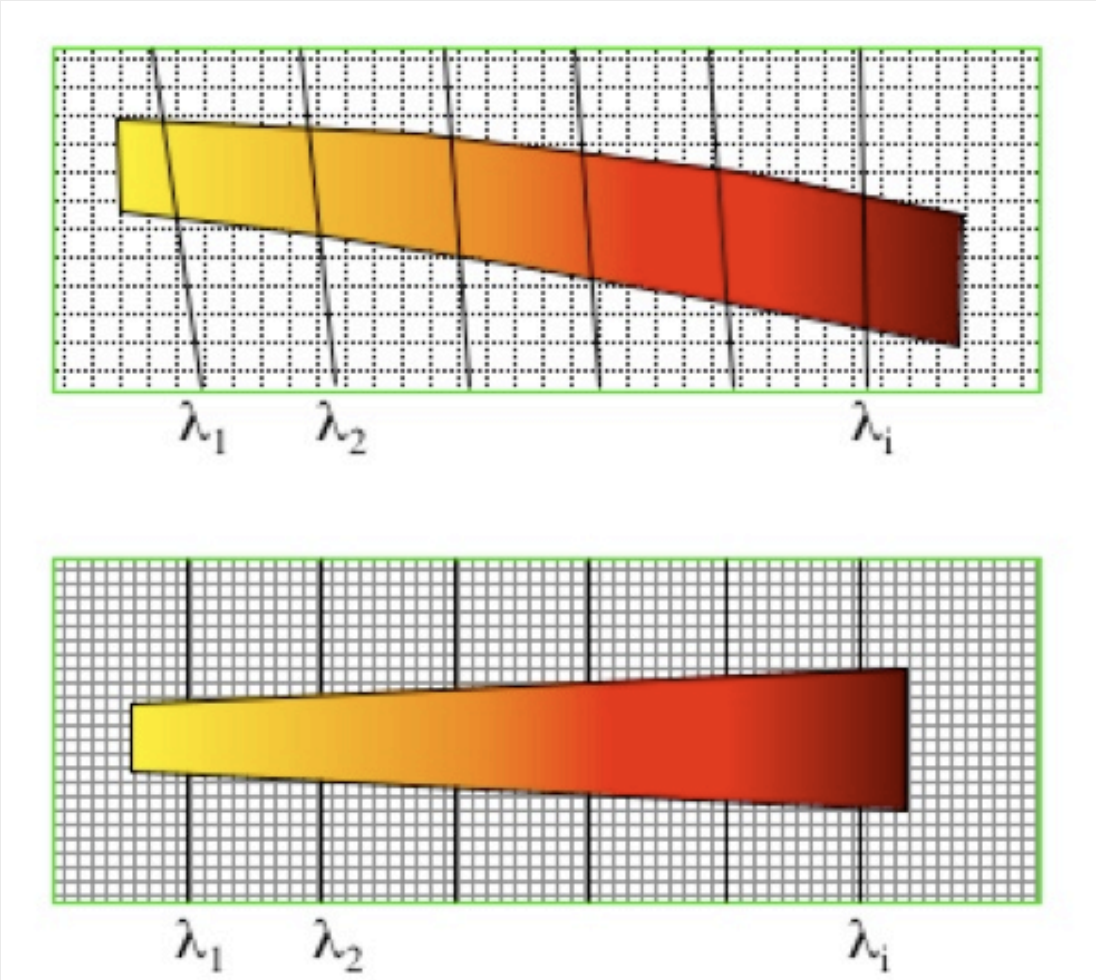


Proper Background Subtraction - Here??

Or Here?

Best Order of Processing steps may depend on data acquisition strategy!

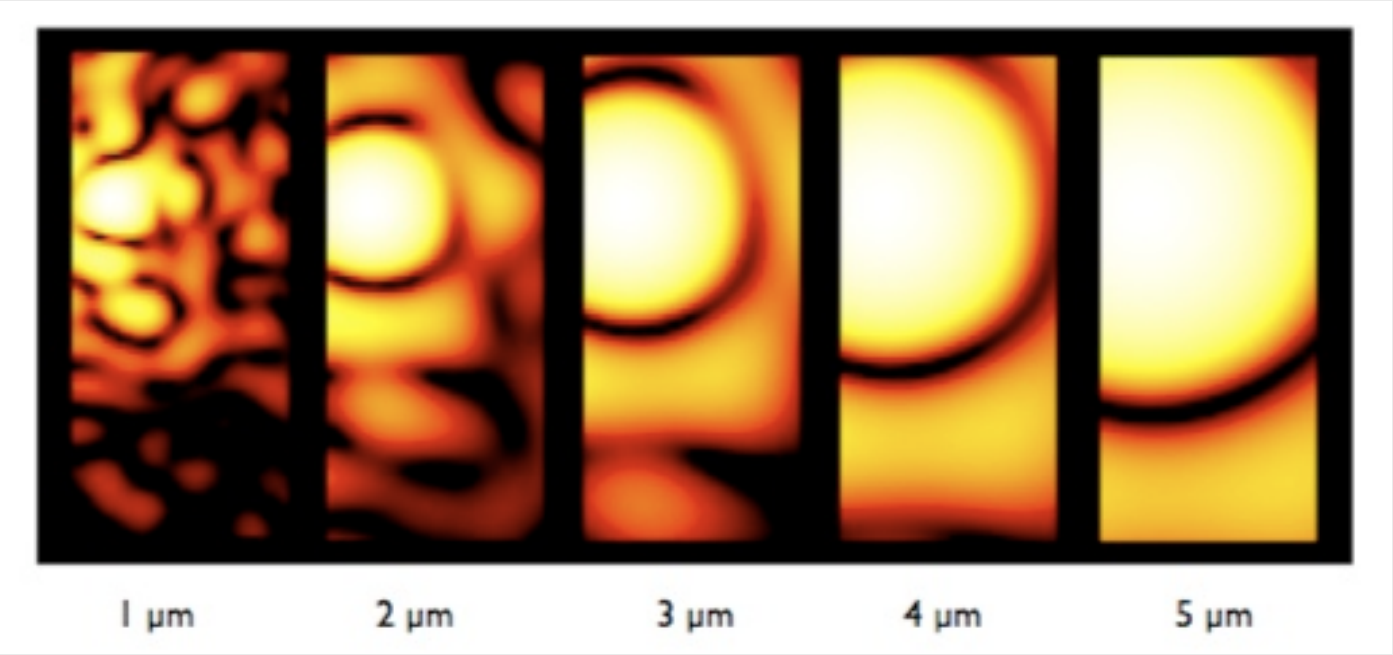
Calibration of NIRSpec Data



NIRSpec Spectra are curved, tilted, flared and irregularly sampled in the detector pixels

Want spectra on a regular pixel grid in spatial and wavelength dimensions

Calibration of NIRSpec Data

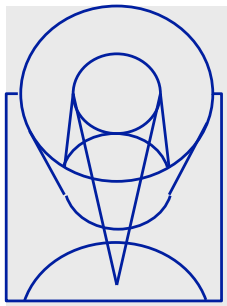


- PSF varies with wavelength - NIRSpec varies by a factor of 5
- Imperfectly centered target results in larger slit losses, which can vary by a lot in wavelength
- Point source versus Galaxy spatial profile?

Data Challenges for NIRSpec

- Flat Field / Throughput - “Model” approach versus Observed Flat
- Proper background flux subtraction?
- Spectral character (tilted, curved spectra)
- Target Centering / Aperture Flux Losses
- Target Profile Shape
- Processing many data files, dithers?

OPEN QUESTION - How much of the data processing can be automated to remove these effects to provide the most useful NIRSpec data product to the user and in the archive?



Goal is Absolute Astronomical Flux Calibration of NIRSpec Spectra to 10% Accuracy!

This will of course be tricky! & it won't be possible for faint targets in all modes

Calibration pipeline will be continually improved - particularly MSA reduction for previous issues - we won't "stop" at 10%

NIRSpec Pipeline Processing - Where we're at…

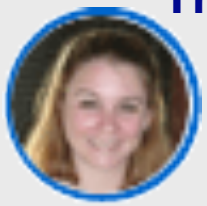
- Presently clarifying the data processing steps and their order, methods to propagate information to the pipeline
- Cross reference processing steps with other JWST instrument teams (particularly for detector processing).
- High - level requirements are being written -requirements review in September (very "high level").
- After ground tests, ESA NIRSpec team will deliver data processing algorithms and calibration reference files to STScI - we will all work together to optimize the pipeline reduction.
- Plan - Tests of NIRSpec pipeline calibration reductions before launch - using NIRSpec ground test data and / or simulated spectra

NIRSpec Team @ STScI!

9 Members (+ ~1 New hire in Fall)

Largest team for JWST at STScI

Future - ~10(?) ESA Employees will work on NIRSpec at STScI!



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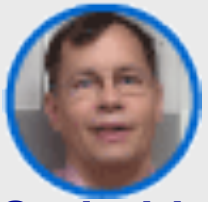
NIRSpec Operations

Mike Regan
NIRSpec Detectors

Doug Long
NIRSpec Detectors

James Muzerolle
NIRSpec Commissioning



Dave Soderblom
NIRSpec Proposal / Planning

Diane Karakla
NIRSpec Proposals

Thanks for your attention!

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