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JWST/MIRI Data Reduction and Products

Stacey N. Bright,[1,2] K. D. Gordon,[1] C. H. Chen,[1] R. Lajoie,[1] R. Azzollini,[3,4] L. Bergeron,[1] P. Bouchet,[5] J. Bouwman,[6] M. Cracraft,[1] S. Fischer,[7,8] S. D. Friedman,[1] M. Garcia-Marin,[8] A. Glasse,[9] A.M. Glauser,[10] G. B. Goodson,[11] T. P. Greene,[12] D.C. Hines,[1] M. A. Khorrami,[1]1 F. Lahuis,[13,14] C.-P. Lajoie,[1] M. E. Meixner,[1,15] J.E. Morrison,[1,16] B. O'Sullivan,[17] K. M. Pontoppidan,[1] M. W. Regan,[1] M. E. Ressler,[11] G. H. Rieke,[16] S. Scheithauer,[6] H. Walker,[18] and G. S. Wright[9]

[1]*Space Telescope Science Institute, USA;* bright@stsci.edu
[2]*Sterrenkundig Observatorium, Universiteit Gent, Belgium*
[3]*Dublin Institute for Advanced Studies, School of Cosmic Physics, Ireland*
[4]*Centro de Astrobiologia (INTA-CSIC), Dpto Astrofisica, Spain*
[5]*Laboratoire AIM Paris-Saclay, France*
[6]*Max Planck Insitut fur Astronomie (MPIA), Germany*
[7]*Deutsches Zentrum fur Luft- und Raumfahrt (DLR), Germany*
[8]*I. Physikalisches Institut. Universitat Koln, Germany*
[9]*UK Astronomy Technology Centre, Royal Observatory, Scotland, UK*
[10]*ETH Zurich, Institute for Astronomy, Switze*
[11]*Jet Propulsion Laboratory, California Institute of Technology, USA*
[12]*Ames Research Center, Moffett Field, USA*
[13]*Leiden Observatory, Leiden University, Netherlands*
[14]*SRON Netherlands Institute for Space Research, Netherlands*
[15]*The Johns Hopkins University, Department of Physics and Astronomy, USA*
[16]*Steward Observatory, University of Arizona, USA*
[17]*Airbus Defence and Space, Hertfordshire, UK*
[18]*RALSpace, STFC, Rutherford Appleton Lab, UK*

Abstract. The Mid-Infrared Instrument (MIRI) is one of four science instruments to be flown aboard the James Webb Space Telescope (JWST). MIRI operates from 5 to 28.5 microns and provides a suite of versatile capabilities including imaging, low-resolution spectroscopy (LRS), medium-resolution spectroscopy (MRS) via an integral field unit, and coronagraphy. The MIRI pipeline consists of three stages: 1) Raw to Slope Images, 2) Calibrated Slope Images, and 3) Multiple Exposures Combined. The pipeline is designed to provide well-calibrated, high level data products that maximize the scientific return from the instrument.

1. The Pipeline

The MIRI data reduction plan is based on extensive testing of the instrument. It is split into three stages: first, the raw data are processed into an uncalibrated slope image; second, each slope image is calibrated; and third, slope images from multiple exposures are combined and processed to produce the final data product. Calibrated mosaics and catalogs of point sources will be produced for imaging observations; extracted spectra will be produced for LRS observations; PSF subtracted images will be produced for coronagraph observations; and spectral cubes will be produced for MRS observations. A visual overview of the pipeline can be found in Figure 1. A full description of the JWST/MIRI pipeline can be found in Gordon et al. (2015).

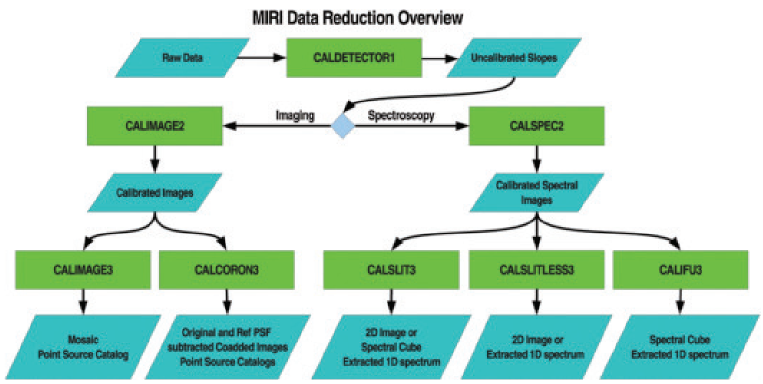

Figure 1. Overview of the JWST/MIRI Pipeline. Image from Gordon et al. (2015).

1.1. Stage 1: Raw to Slope Image

In stage 1 of the pipeline (CALDECTOR1) non-ideal detector characteristics, such as non-linearity, reset anomaly, and latent images, are present in the raw data and are corrected before determining the uncalibrated slope (in DN/s) of each pixel.

1.2. Stage 2: Calibrated Slope Image

Stage 2 corrects for pixel- and time-dependent effects (including residual persistence correction, and flat-fielding) to produce calibrated images in physical units. The pipeline splits here depending on whether the observation is imaging/coronagraphy or spectroscopy. For imaging/coronagraphy (CALIMAGE2) spatial mapping and absolute photometric calibration are performed. For spectroscopy (CALSPEC2) straylight corrections, MRS fringing corrections, spatial and spectral mapping, and LRS compact source background subtraction/extraction are performed.

1.3. Stage 3: Multiple Exposure Combined

Stage 3 processes multiple exposures and extracts information for specific sources to produce high quality final data products that are ready for science analysis.

For imaging observations (CALIMAGE3) the following steps are completed: background matching, cosmic ray detection, self-calibration, and source extraction. For coronagraphy (called CALCORON3) the central source PSF is suppressed/removed, image coaddition is completed, as well as reference PSF subtraction.

For LRS spectroscopy (CALSLIT3) observations of point sources yields compact source combined spectra, and observations of extended sources (taken with mapping dither patterns) yields a spectral cube. LRS slitless spectroscopy (CALSLITLESS3) is intended for high precision observations of variable sources (e.g. exoplanet transients).

For MRS Spectroscopy (CALIFU3) the following steps are completed: background subtraction, spectral cube construction, and extraction of sources from the individual exposures.

2. Data Products

Examples of high-level data products that the pipeline will produce are shown in Figures 2 - 4. In Figure 2, a final mosaicked image of a galaxy, which was observed following a 12-point Reuleaux dither pattern, is shown. A typical coronagraphy observing squence and final PSF subtracted image is shown in Figure 3. Figure 4 shows a common LRS observation set, a nodded observation of a single source. The nods are done at two positions in the slit; the source spectrum can then be extracted directly from the difference image. Figure 5 shows the construction of a full MRS spectral cube. This full spectral cube can be pictured to be composed of four spectral cubes, one for each IFU.

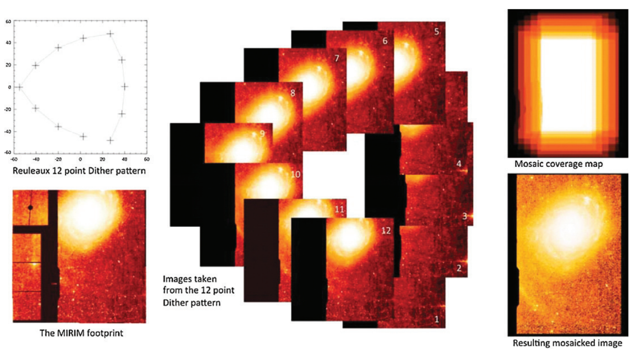

Figure 2. An example of a typical imaging sequence. Images with the 12-point dither pattern are shown separately and then combined into a mosaic. Image from Gordon et al. (2015).

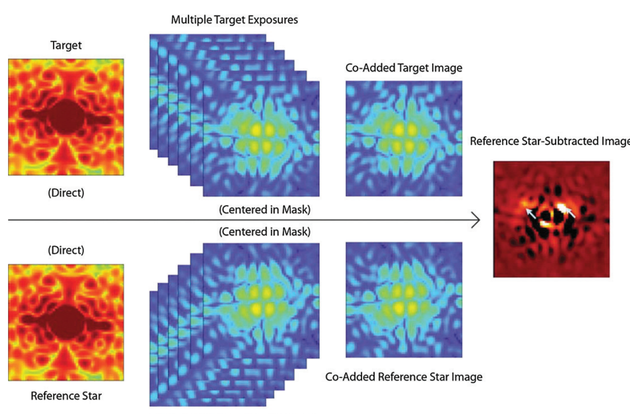

Figure 3. An example of a typical coronagraphy sequence. Images of the target and reference stars are combined to yield a subtraction of the reference star PSF from the target star, revealing faint companions. Image from Gordon et al. (2015).

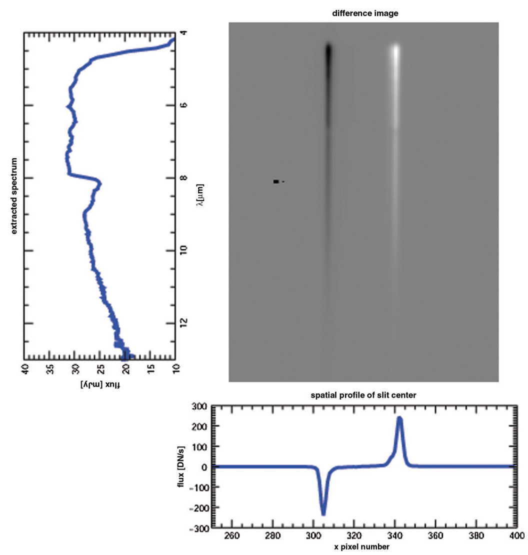

Figure 4. A point source is observed in two different positions in the slit; differencing the two removes the background, as shown in the gray-scale image. Image from Gordon et al. (2015).

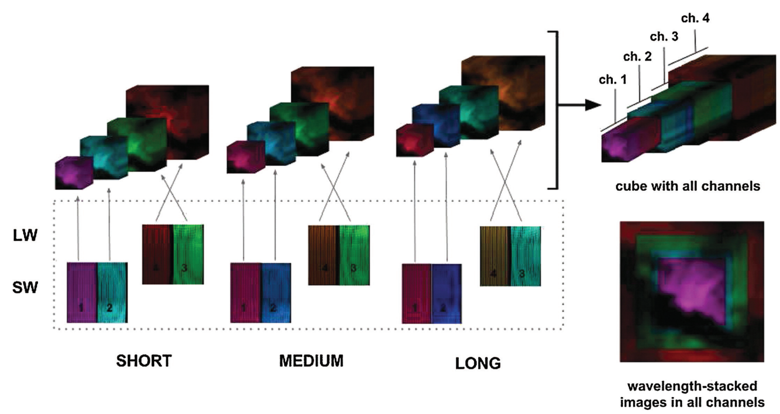

Figure 5. An extended source is observed with three grating settings to obtain full spectral coverage in all four IFUs. Image from Gordon et al. (2015).

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References

Gordon, K. D., et al. 2015, PASP, 127, 696