MIRI Medium Resolution Spectroscopy Template APT Guide

Instructions are available for filling out the JWST APT MIRI MRS template, which is used for integral field unit spectroscopy above 5 μm.

Introduction

Medium-resolution spectroscopy is one of 4 observing modes available with the the Mid-Infrared Instrument (MIRI). The MIRI medium-resolution spectrometer (MRS) will be used to obtain simultaneous spatial and spectral information between 5 and 28.8 μm over a contiguous field of view up to 7.2" × 7.9" in size. The MRS is the only JWST observing mode offering spectroscopy (R = 1500–3500) longward of 12 μm. MRS observations are carried out using a set of 4 integral field units (IFUs), each of which covers a different portion of the MIRI wavelength range. The MRS IFUs use slicers to split the field of view into spatial slices. Each slice produces a separate dispersed "long-slit" spectrum. Post-processing produces a 3-dimensional (2 spatial and one spectral dimension) data cube.

MRS operations have been designed to allow for efficient observations of point sources, compact sources, and extended sources. The observer will have control over 3 primary variables for MRS spectroscopy:
1) wavelength coverage
2) dithering pattern
3) detector readout mode and exposure time (via the number of frames and integrations)

Allowed values are documented and maintained in the MIRI MRS template parameters, but described below.

Step-by-Step APT Instructions

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Target Acquisition Parameters

This field specifies the ***ACQ TARGET***, ***ACQ FILTER***, and ***ACQ EXPOSURE TIME***.

Target ACQ

For MRS spectroscopy, choose ***ACQ TARGET*** from the pull down menu. ***FILTERS*** available include: ***F560W***, ***F1000W***, ***F1500W***, and ***FND***. As of APT 25.4.2 it is also allowed to select 'NONE' for the target acquisition, which will disable target acquisition for the observation.

ACQ Exposure Time

A Target ACQ must be completed by selecting a MULTIACCUM exposure configuration. Each exposure is configured by setting the readout pattern and characteristics parameters: ***READOUT PATTERN*** and ***NUMBER OF GROUPS***.

> Users should use the Exposure Time Calculator (ETC) to *determine the best exposure configuration to optimize the signal-to-noise.*

ACQ READOUT PATTERN

1. *FAST* (default)
2. *SLOW*
3. *FASTGRPAVG*

NUMBER OF GROUPS AND INTEGRATIONS

The MIRI readout timing pattern in the ACQ exposure is defined by only one of the MULTIACCUM parameters:

1. ***ACQ NUMBER OF GROUPS***: the number of groups during an integration, where a group is the product of cycling through all the pixels

ACQ NUMBER OF INTEGRATIONS and ***ACQ PHOTON COLLECTION DURATION*** are not user changeable.

MRS Parameters

Primary Channel

The ***PRIMARY CHANNEL*** defines the pointing origin (i.e., where the science target would be centered in the absence of dithering), available dither patterns, and field boundaries (for mosaic overlap calculations). Options include:

1. *ALL**
2. *CH1*
3. *CH2*
4. *CH3*

5. *CH4*

*The default choice should be **ALL**, unless the science case wishes to prioritize data quality in a particular wavelength channel at the expense of other wavelengths (e.g., maximizing long-wavelength source separation at the possible expense of the target not being in the short-wavelength field of view).

Dithers

The ***DITHERS*** dialog box handles the creation of dither patterns, which must be created before defining your exposure sequence. Each ***DITHER*** is specified by setting several parameters: ***DITHER TYPE***, ***OPTIMIZED FOR***, and ***DIRECTION***.

DITHER TYPE

1. ***2-POINT*** dithering allows for basic image separation in order to use one exposure as the 'background image' for another, and to detect the source with redundant detector pixels. It achieves optimal half-integer spatial sampling throughout much of the field of view.
2. ***4-POINT*** dithering achieves optimal half-integer spatial sampling throughout the entire field of view of all 4 channels.

The default choice should be ***4-POINT*** unless spatial image quality is not a priority to the science case. Dithering may be turned off in order to create zero-offset exposures in the Exposure Parameters table.

OPTIMIZED FOR

1. Either the Primary Channel chosen above
2. ***EXTENDED***

The ***PRIMARY CHANNEL*** dithering schemes provide the maximum possible separation between the dither locations. The ***EXTENDED*** dithering scheme provides the minimum possible separation that still achieves ideal spatial sampling and use of redundant detector locations. When observing point sources or otherwise small objects, the ***PRIMARY CHANNEL*** dithering scheme should generally be selected. When observing extended sources that fill much of the field of view, or when mosaicing together multiple pointings, some science cases may wish to use the ***EXTENDED*** scheme. Note that programs using the ***EXTENDED*** pattern should also include a separate dedicated background exposure at an off-source location since the image separation achieved in this dither scheme will be insufficient to achieve proper background subtraction.

DIRECTION

1. ***POSITIVE***
2. ***NEGATIVE***

This choice defines the orientation of the dither offsets in the JWST focal plane; they are mirror symmetric with respect to the IFU slice orientation and achieve identical sampling. This option is provided to allow for flexibility in dithering direction if the telescope ORIENT is to be fixed for a given observation. The default is ***NEGATIVE***, and is unimportant for the majority of science cases.

Science Exposures

SIMULTANEOUS IMAGING

MIRI offers the ability to obtain simultaneous imaging with the MIRI imager while obtaining MRS spectroscopy. Choose:

1. *YES*
2. *NO*

IMAGER SUBARRAY

If you choose simultaneous imaging, MIRI imaging supports the use of a pre-defined set of ***SUBARRAYS*** for observing targets bright enough to saturate the image in full-frame readout. Each subarray is a associated with a brightness limit, depending on the filter used, above which a point source will saturate in the shortest 2-group integration. A MIRI simultaneous imaging observation can only support a single subarray. If the target must be imaged using another subarray, it is necessary to create another MIRI simultaneous imaging observation.

Subarray	Size (pixels)	Usable size (arcsec)	Frame time (s)
FULL	1024 × 1032	74 × 113	2.775
BRIGHTSKY	512 × 512	56.3 × 56.3	0.865
SUB256	256 × 256	28.2 × 28.2	0.300
SUB128	128 × 136	14.1 × 14.1	0.119
SUB64	64 × 72	7 × 7	0.085

Exposure Parameters

Users should use the Exposure Time Calculator (ETC) to *determine the best exposure configuration to optimize the signal-to-noise.*

An MRS sequence is specified by first setting the ***WAVELENGTH RANGE*** desired for each exposure. There are three available settings: SHORT (A), MEDIUM (B), and LONG (C). Each setting covers one third of the wavelength range of each channel; a full observation from 5-28 μm would thus require an exposure at each of these three settings.

Each sequence must then be completed by selecting a MULTIACCUM exposure configuration for each detector being used (in the ***EXPOSURE PARAMETERS*** dialog box). Each exposure is configured by setting the readout pattern and characteristics parameters: ***READOUT PATTERN***, ***NUMBER OF GROUPS***, and ***NUMBER OF INTEGRATIONS***. If you choose simultaneous imaging, you must select an imaging ***FILTER*** for each MRS sequence. Each MRS sequence can support only a single imaging ***FILTER***. Finally select a dither pattern from the list of ***DITHERS*** already defined for the observation (or 'None' for no dithering). The exposures will be repeated at each dither position following an offset of the telescope to the new position. The number of exposures at each dither position is set by ***NO. OF EXPOSURES,*** but this input must be the same for all detectors.

READOUT PATTERN

MIRI offers two readout modes:

1. Fast (default for imaging detector)
2. Slow (default for MRS detectors)

NUMBER OF GROUPS AND INTEGRATIONS

The MIRI timing pattern per exposure is defined by only two MULTIACCUM parameters:

1. ***NUMBER OF GROUPS*****:** the number of groups during an integration, where a group is the product of cycling through all the pixels
2. ***NUMBER OF INTEGRATIONS*****:** the number of integrations during an exposure, where integration is defined as the time between resets.

Mosaic Properties

The MIRI MRS may be used to obtain data for a region larger than their size by creating a MIRI MRS mosaic pattern.

Special Requirements

A variety of observatory level special requirements may be chosen.

Comments

The comments field should be used only to record observing notes.