# Chapter 19

**MIRI Engineering**

**In this chapter…**

## Introduction

The MIRI Engineering templates/modes are used for calibration observations for the MIRI detectors. These observations may be to obtain darks, internal flat fields, wavelength calibrations, coronagraphic photometric calibrations,or to perform anneals. The parameters described in this section are used to specify the Observations for MIRI Engineering modes. More complete descriptions of the detector readout parameters, filters, detector characteristics, etc. are available in the MIRI Instrument Handbook.

The following fields are defined in Chapter 5: Observation Number (5.1), Observation Label (5.2), Observation Comments (5.3), Target Name (5.4), and Observation-Level Special Requirements (5.5), and will not be discussed in this Chapter.

The MIRI Engineering templates consist of the following parameters:

|  |  |  |  |
| --- | --- | --- | --- |
| Field | Details | Values | Notes |
| **Dark** [MIR0130] |
| Detector [MIR0322] | select Detector | choose from list [MIR0131] |  |
| Number of Exposures [MIR0323] | specify number of times to repeat the dark exposure | number [MIR0132] |  |
| Subarray [MIR0268] | specify the subarray | choose from list [MIR0074] | See Table 19-1 |
| Readout Pattern [MIR0326] | select readout pattern | choose from list [MIR0135] |  |
| Number of Groups Long [MIR0458] | specify number of groups on the long wavelength detector | Number [MIR0459] |  |
| Number of Groups Short [MIR0460] | specify number of groups on the short wavelength detector | Number [MIR0461] |  |
| Number of Integrations Long [MIR0080] | specify number of integrations on the long wavelength detector | Number [MIR0081] |  |
| Number of Integrations Short [MIR0082] | specify number of integrations on the short wavelength detector | Number [MIR0083] |  |
| **Imager Flat** [MIR0136] |
| Target Name [MIR0538] | select Target Name | choose from list [MIR0539] | from Target list |
| Gaussian Dither [MIR0540] | select if Gaussian Dither pattern desired | YES, NO [MIR0541] |  |
| Lamp Use [MIR0542] | select if observation with lamp off is desired | ON ONLY, OFF THEN ON [MIR0543] |  |
| Filter [MIR0328] | select Filter | choose from list [MIR0138] | See Table 19-2 |
| Number of Groups [MIR0553] | specify number of groups | Number [MIR0554] |  |
| Number of Integrations [MIR0329] | specify number of integrations | number [MIR0139] |  |
| **MRS Flat** [MIR0140] |
| Target Name [MIR0544] | select Target Name | choose from list [MIR0545] | from Target list |
| Gaussian Dither [MIR0546] | select if Gaussian Dither pattern desired | YES, NO [MIR0547] |  |
| Lamp Use [MIR0548] | select if observation with lamp off is desired | ON ONLY, OFF THEN ON [MIR0549] |  |
| Wavelength1&4 [MIR0331] | specify Wavelength | choose from list [MIR0142] | See Table 19-3 |
| Wavelength2&3 [MIR0330] | specify Wavelength | choose from list [MIR0141] |  |
| Number of Groups Long [MIR0324] | specify number of groups on the long wavelength detector | Number [MIR0325] |  |
| Number of Groups Short [MIR0133] | specify number of groups on the short wavelength detector | Number [MIR0134] |  |
| Number of Integrations Long [MIR0332] | specify number of integrations on the long wavelength detector | Number [MIR0143] |  |
| Number of Integrations Short [MIR0555] | specify number of integrations on the short wavelength detector | Number [MIR0556] |  |
| **Anneal** [MIR0144] |
| Detector [MIR0333] | select Detector | choose from list [MIR0145] |  |
| **Wavelength Calibration** |
| TBD |  |  |  |
| **Coronagraphic Photometric Calibrations** [MIR0327] |
| Target Name [MIR0137] | select Target Name | Choose from list [MIR0269] | From Target list |
| Pattern Size [MIR0075] | select dither pattern size | choose from list [MIR0273] |  |
| Subpixel Sampling [MIR0079] | select if sampling desired | YES, NO [MIR0439] |  |
| Subarray [MIR0440] | select Subarray | choose from list [MIR0441] |  |
| Filter(s) [MIR0442] | select filter name(s) | choose from list [MIR0084] | See Table 19-5 |
| Readout Pattern [MIR0472] | select readout pattern | choose from list [MIR0473] |  |
| Number of Groups [MIR0085] | select number of groups | number [MIR0086] |  |
| Number of Integrations [MIR0097] | select number of integrations | number [MIR0337] |  |

## Dark

These parameters are required to obtain Dark observations. Note that this type of observation can be obtained as a parallel to normal science observations [MIR0146].

### Detector

#### DETECTOR [DETECTOR] = IMAGER [MIR0147], MRS [MIR0148]

 This parameter specifies the detector that is to be used.

For developers: users can specify one or more combinations of the parameters below for DARKs [MIR0334].

### Number of Exposures

**NUMBER OF EXPOSURES [NEXP]** specifies the number of times the dark exposure is to be repeated [MIR0149].

### 19.2.3 Subarray

**SUBARRAY [SUBARRAY] = FULL [MIR0098], BRIGHTSKY [MIR0099], SUB256 [MIR0295], SUB128 [MIR0296], SUB64 [MIR0297], SUBPRISM [MIR0474], MASK1550 [MIR0475], MASK1140 [MIR0476], MASK1065 [MIR0477], MASKLYOT [MIR0478]**

This parameter specifies the region of the detector that is to be read out. See Table 19-1 for details. Note that this parameter is only valid for **DETECTOR**=**IMAGER [MIR0479]**.

Table 19‑ Subarrays for MIRI Dark

|  |  |  |  |
| --- | --- | --- | --- |
| Subarray | Rows | Columns | Light Sensitive Columns |
| FULL | 1024 | 1032 | 1024 |
| BRIGHTSKY | 512 | 968 | 964 |
| SUB256 | 256 | 668 | 664 |
| SUB128 | 128 | 136 | 132 |
| SUB64 | 64 | 72 | 68 |
| SUBPRISM | 512 | 72 | 68 |
| MASK1550 | 224 | 288 | 284 |
| MASK1140 | 224 | 288 | 284 |
| MASK1065 | 224 | 288 | 284 |
| MASKLYOT | 304 | 320 | 316 |

###  Exposure Duration

The following parameters define a dark exposure [MIR0150].

####  Readout pattern

#### READOUT PATTERN [READOUT PATTERN] = SLOW [MIR0153], FAST [MIR0154], FASTGRPAVG [MIR0456], FASTINTAVG [MIR0457]

This field specifies the readout pattern to be used to obtain the data. **FAST** is used for bright targets and long wavelength imaging, **SLOW** is used for faint targets, deep imaging, and MRS spectroscopy, **FASTGRPAVG** and **FASTINTAVG** are used for bright targets and to decrease the data rate.

####  Number of Groups

For **DETECTOR = IMAGER**, specify the following:

**NUMBER OF GROUPS [NGROUPS]** specifies the number of groups in an integration [MIR0151].

For **DETECTOR = MRS**, specify the following:

**NUMBER OF GROUPS LONG [NGROUPSLONG]** specifies the number of groups in an integration on the long wavelength detector [MIR0479].

**NUMBER OF GROUPS SHORT [NGROUPSSHORT]** specifies the number of groups in an integration on the short wavelength detector [MIR0100].

If **READOUT PATTERN** = **FASTGRPAVG**, then the number of groups should be greater than 16 [MIR0101] and a multiple of 4 [MIR0102]. If **READOUT PATTERN** = **FASTINTAVG**, then the number of groups should be 1 [MIR0480].

####  Number of integrations

For **DETECTOR = IMAGER**, specify the following:

**NUMBER OF INTEGRATIONS [NINTS]** field specifies the number of times the integration is repeated [MIR0152].

For **DETECTOR = MRS**, specify the following:

**NUMBER OF INTEGRATIONS LONG [NINTSLONG]** field specifies the number of times the integration is repeated on the long wavelength detector [MIR0481].

**NUMBER OF INTEGRATIONS SHORT [NINTSSHORT]** field specifies the number of times the integration is repeated on the short wavelength detector [MIR0482].

If **READOUT PATTERN** = **FASTINTAVG**, then the number of integrations should be a multiple of 4 [MIR0483].

When obtaining data, the exposure time for both the LONG and SHORT detectors must be identical. Therefore when the **DETECTOR** is **MRS,** the parameters for groups and integrations must conform to the following restriction:

 **NUMBER OF INTEGRATIONS (LONG)** \* **NUMBER OF GROUPS (LONG)** =

 **NUMBER OF INTEGRATIONS(SHORT)** \* **NUMBER OF GROUPS( SHORT)** [MIR0103]

## Imager Flat

These parameters are required to obtain Imager Flat observations. Note that this type of observation cannot be obtained as a parallel to normal science observations [MIR0155], but can be in parallel with slews [MIR0156] except where the parameter **LAMP USE = OFF THEN ON** [MIR0550]**,** a **TARGET NAME** is specified [MIR0551], or where **GAUSSIAN DITHER = YES** [MIR0552].

### 19.3.1 Target Name

Select the **TARGET NAME** **[TBD]** [MIR0557] from the list of targets previously entered (see Section 5.4).

### 19.3.2 Dither Pattern

**GAUSSIAN DITHER = YES** [MIR0558]**, NO** [MIR0559]

This field indicates if dithering is desired. When set to yes, a 5-position large Gaussian dither (see Figure 19.1) will be used [MIR0560].

Note for developer: This is the equivalent of setting the following parameters: PATTERN TYPE = GAUSSIAN, PATTERN SIZE=LARGE, and SUBARRAY=FULL. When set to yes, APT needs to populate the dither\_id on the exposure\_spec table [MIR0561]. This means that each exposure spec will create a dither record, and add the ID of that record onto the exposure table.

### 19.3.3 Lamp Use

**LAMP USE = ON ONLY** [MIR0562]**, OFF THEN ON** [MIR0563]

This field indicates if the calibration is to be executed twice; first with the calibration lamp OFF, then with the calibration lamp **ON**. This is done in order to permit subtraction of external objects from the lamp on data. Note that if **OFF THEN ON** is requested, you will be prompted separately for the **NUMBER OF INTEGRATIONS** for the **OFF** exposures and the **ON** exposures [MIR0564].

Note for developer: If **LAMP USE = ON ONLY**, then populate Lamp Power field in the exposure spec **[LAMP\_POWER]** with **ON** [MIR0565]. If **LAMP USE = OFF THEN ON**, then populate Lamp Power field in the exposure spec **[LAMP\_POWER]** with all the **OFF** exposures then all the **ON** exposures [MIR0566].

### 19.3.4 Filters

For each filter that you use, specify the name of the filter and the requested exposure parameters [MIR0567].

#### Filter

Select the name of the **FILTER** [FILTER] (see Table 19-2) you wish to use.

Table 19-2 Filters Available for MIRI Imager Internal Flat Observations

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Filter |  | Center Wavelength 0 (m) | Filter Bandpass (m) | Maximum number of integrations |  |
| F560W | [MIR0162] | 5.6 | 1.2 | TBD | [MIR0177] |
| F770W | [MIR0163] | 7.7 | 2.2 | TBD | [MIR0178] |
| F1000W | [MIR0164] | 10.0 | 2.0 | TBD | [MIR0179] |
| F1065C | [MIR0165] | 10.7 | 0.5 | TBD | [MIR0180] |
| F1130W | [MIR0166] | 11.3 | 0.7 | TBD | [MIR0181] |
| F1140C | [MIR0167] | 11.4 | 0.6 | TBD | [MIR0182] |
| F1280W | [MIR0168] | 12.8 | 2.4 | TBD | [MIR0183] |
| F1500W | [MIR0169] | 15.0 | 3.0 | TBD | [MIR0184] |
| F1550C | [MIR0170] | 15.5 | 0.8 | TBD | [MIR0185] |
| F1800W | [MIR0171] | 18.0 | 3.0 | TBD | [MIR0186] |
| F2100W | [MIR0172] | 21.0 | 5.0 | TBD | [MIR0187] |
| F2300C | [MIR0173] | 23.0 | 4.6 | TBD | [MIR0188] |
| F2550W | [MIR0174] | 25.5 | 4.0 | TBD | [MIR0189] |
| F2550WR | [MIR0175] | 25.5 | 4.0 | TBD | [MIR0190] |
| FND | [MIR0342] |  |  | TBD | [MIR0343] |
| P750L | [MIR0176] | 7.5 |  | TBD | [MIR0191] |

#### 19.3.4.2 Number of Groups

**NUMBER OF GROUPS [NGROUPS]** specifies the number of groups in an integration on the imager detector [MIR0568]. The default value is 4 [MIR0569].

Note to developer: if **NGROUPS is** less than 4, APT should issue a stern warning [MIR0570].

#### Number of integrations

This field specifies the **NUMBER OF INTEGRATIONS [NINTS]** to be obtained for each filter [MIR0192]. Note that there is a maximum number for this parameter based on the **FILTER** selected (see Table 19-2) [MIR0193].

Developer's note: The remaining parameters needed to complete the exposure are PATTERN=FAST, SUBARRAY=FULL, and NGROUPS (see Table 19-2); these will be set in the scripts [MIR0571].

## MRS Flat

These parameters are required to obtain MRS Flat observations. Note that this type of observation cannot be obtained as a parallel to normal science observations [MIR0194], but can be in parallel with slews [MIR0195] except where the parameter **LAMP USE = OFF THEN ON** [MIR0572]**,** a **TARGET NAME** is specified [MIR0573], or where **GAUSSIAN DITHER = YES** [MIR0574].

### 19.4.1 Target Name

Select the **TARGET NAME** **[TBD]** [MIR0575] from the list of targets previously entered (see Section 5.4).

### 19.4.2 Dither Pattern

**GAUSSIAN DITHER = YES** [MIR0576]**, NO** [MIR0577]

This field indicates if dithering is desired. When set to yes, a 5-position large Gaussian dither (see Figure 19.1) will be used [MIR0578].

Note for developer: This is the equivalent of setting the following parameters: PATTERN TYPE = GAUSSIAN, PATTERN SIZE=LARGE, and SUBARRAY=FULL. When set to yes, APT needs to populate the dither\_id on the exposure\_spec table [MIR0579]. This means that each exposure spec will create a dither record, and add the ID of that record onto the exposure table.

### 19.4.3 Lamp Use

**LAMP USE = ON ONLY** [MIR0580]**, OFF THEN ON** [MIR0581]

This field indicates if the calibration is to be executed with the calibration lamp off as well in order to permit subtraction of external objects from the lamp on data. Note that if **OFF THEN ON** is requested, you will be prompted separately for the **NUMBER OF INTEGRATIONS** for the **OFF** exposures and the **ON** exposures [MIR0582].

Note for developer: If **LAMP USE = ON ONLY**, then populate Lamp Power field in the exposure spec **[LAMP\_POWER]** with **ON** [MIR0583]. If **LAMP USE = OFF THEN ON**, then populate Lamp Power field in the exposure spec **[LAMP\_POWER]** with all the **OFF** exposures then all the **ON** exposures [MIR0584].

### 19.4.4 Wavelengths

For each wavelength pair you use, specify the name of the wavelength regions and the requested exposure parameters [MIR0585].

#### Wavelength

#### WAVELENGTH1&4 [WAVELENGTH1&4] = SHORT [MIR0200], MEDIUM [MIR0201], LONG [MIR0202]

#### WAVELENGTH2&3 [WAVELENGTH2&3] = SHORT [MIR0196], MEDIUM [MIR0197], LONG [MIR0198]

Select the wavelength region (see Table 19-3) you wish to use for channels 1 and 4, and for channels 2 and 3.

Table 19-3 Wavelength Regions Available for MIRI MRS Internal Flat Observations

|  |  |  |  |
| --- | --- | --- | --- |
| WavelengthRegion | Wavelength Ranges Δ(m) | Maximum number of integrations |  |
| SHORT | 4.87-5.82 | 7.45-8.90 | 11.47-13.67 | 17.54-21.10 | TBD | [MIR0203] |
| MEDIUM | 5.62-6.73 | 8.61-10.28 | 13.25-15.80 | 20.44-24.72 | TBD | [MIR0204] |
| LONG | 6.49-7.76 | 9.94-11.87 | 15.30-18.24 | 23.84-28.82 | TBD | [MIR0205] |

#### 19.4.4.2 Number of Groups

**NUMBER OF GROUPS LONG [NGROUPSLONG]** specifies the number of groups in an integration on the long wavelength detector [MIR0586]. The default value is 4 [MIR0587].

**NUMBER OF GROUPS SHORT [NGROUPSSHORT]** specifies the number of groups in an integration on the short wavelength detector [MIR0588]. The default value is 4 [MIR0589].

Note to developer: if **NGROUPS LONG** or **SHORT** is less than 4, APT should issue a stern warning [MIR0590].

####  Number of integrations

**NUMBER OF INTEGRATIONS LONG [NINTSLONG]** field specifies the number of times the integration is repeated on the long wavelength detector [MIR0206].

**NUMBER OF INTEGRATIONS SHORT [NINTSSHORT]** field specifies the number of times the integration is repeated on the short wavelength detector [MIR0207].

Developer's note: The remaining parameters needed to complete the exposure are PATTERN=FAST, SUBARRAY=FULL, NGROUPSLONG=8, and NGROUPSSHORT=8; these will be set in the scripts [MIR0591].

## Anneal

This parameter is required to obtain Anneal observations. Note that this type of observation can be obtained as a parallel to normal science observations [MIR0208].

Detector anneals will be performed to treat cosmic ray damage. During the anneals, MIRI will be heated up to ~15-20K above its nominal operating temperature and will not be useable.

### Detector

#### DETECTOR [DETECTOR] = IMAGER [MIR0209], MRSLONG [MIR0210], MRSSHORT [MIR0211]

This parameter specifies the detector that is to be used.

## Wavelength Calibration

These parameters are required to obtain Wavelength Calibration observations. Details are TBD.

##

## 19.7 Coronagraphic Photometric Calibration

The Coronagraphic Photometric Calibration observation will use a 4-points-of-light strategy to improve sampling of the PSF in multiple locations on the detector. Those points are described in Table 19-4 below. At each of these points, the entire Dither pattern selected below will be executed **[MIR0491]**.

Table 19-4 Points-of-Light for Coronagraphic Photometric Calibration Observations

|  |  |
| --- | --- |
| Mask | X,Y Positions (arcsecs) |
|  | 1 | 2 | 3 | 4 |
| MASK1065 | -5.94, 5.94 **[MIR0278]** | 5.94, 5.94 **[MIR0279]** | 5.94, -5.94 **[MIR0280]** | -5.94, -5.94 **[MIR0281]** |
| MASK1140 | -5.94, 5.94 **[MIR0484]** | 5.94, 5.94 **[MIR0485]** | 5.94, -5.94 **[MIR0486]** | -5.94, -5.94 **[MIR0487]** |
| MASK1550 | -5.94, 5.94 **[MIR0482]** | 5.94, 5.94 **[MIR0483]** | 5.94, -5.94 **[MIR0484]** | -5.94, -5.94 **[MIR0485]** |
| MASKLYOT | -6.27, 7.37 **[MIR0486]** | 6.27, 7.37 **[MIR0488]** | 6.27, -7.37 **[MIR0489]** | -6.27, -7.37 **[MIR0490]** |

Note for developers: This pattern will be implemented as a canned mosaic, and no further mosaic parameters should be allowed **[MIR0287]**. APT should default to include a NO PARALLEL special requirement when the template is created **[MIR0288]**, but the user should be allowed to remove it if necessary **[MIR0289]**.

The following parameters are used for Coronagraphic Photometric Calibration exposures.

### 19.7.1 Target Name

Select the **TARGET NAME** **[TBD]** from the list of targets previously entered (see Section 5.4). **[MIR0010]**

### 19.7.2 Dither Pattern

Coronagraphic Photometric Calibrations with the JWST will require dithering. A Gaussian dither pattern of a user selectable size will be available for MIRI Coronagraphic Photometric Calibration observations. The dither pattern will be executed at each of the points-of-light defined above **[MIR0490]**.

The GAUSSIAN pattern is shown in Figure 19.1, and is designed for observing bright objects on small subarrays. To provide optimized sub-pixel sampling, this pattern should be used in conjunction with the sub-pixel sampling option.

Figure 19. The GAUSSIAN Pattern



The origin is the aperture center.

#### 19.7.2.1 Pattern Size

**PATTERN SIZE [PATTERN\_SIZE] = DEFAULT (default) [MIR0290], SMALL [MIR0291], MEDIUM [MIR0292]**

This parameter specifies that all exposures are to be done with the same dithering pattern (**SMALL** or **MEDIUM**). When the pattern size is not specified by the user the **DEFAULT** pattern will be used based upon the choice of filter. For the F560W, the **SMALL** size will be used, while for all other filters the **MEDIUM** size will be used.

|  |  |  |
| --- | --- | --- |
| Filter | Default Pattern Size |  |
| FND | MEDIUM | **[MIR0448]** |
| F1000W | MEDIUM | **[MIR0449]** |
| F1500W | MEDIUM | **[MIR0305]** |
| F560W | SMALL | **[MIR0306]** |
| F1065C | MEDIUM | **[MIR0307]** |
| F1140C | MEDIUM | **[MIR0127]** |
| F1550C | MEDIUM | **[MIR0128]** |
| F2300C | MEDIUM | **[MIR0308]** |

#### 19.7.2.2 Subpixel Sampling

**SUBPIXEL SAMPLING [SUBPIXEL\_SAMPLING] = YES [MIR0113], NO [MIR0114]**

This parameter specifies whether or not subpixel sampling (a Parallelogram pattern) will be performed.

Note for developers: see Appendix F1 for dithering details.

### 19.7.3 Subarray

**SUBARRAY [SUBARRAY] = MASK1550 [MIR0309], MASK1140, [MIR0310] MASK1065 [MIR0311], MASKLYOT [MIR0312]**

This parameter specifies the region of the detector that is to be used.

For a single **SUBARRAY** observation several filters are allowed **[MIR0386]**. The following table shows the available **FILTER**s for the selected **SUBARRAY**.

|  |  |
| --- | --- |
| Subarray | Filter |
| MASK1065  | FND **[MIR0313]**, F1000W **[MIR0314]**, F1500W **[MIR0315]**, F560W **[MIR0316]**, F1065C **[MIR0317]** |
| MASK1140  | FND **[MIR0318]**, F1000W **[MIR0319]**, F1500W **[MIR00054]**, F560W **[MIR0265]**, F1140C **[MIR0266]** |
| MASK1550 | FND **[MIR0267]**, F1000W **[MIR0066]**, F1500W **[MIR0067]**, F560W **[MIR0068]**, F1550C **[MIR0069]** |
| MASKLYOT | FND **[MIR0248]**, F1000W **[MIR0249]**, F1500W **[MIR0250]**, F560W **[MIR0251]**, F2300C **[MIR0252]** |

### 19.7.4 Filters

For each filter that you use, specify the name of the filter and the requested exposure parameters **[MIR0253]**.

#### 19.7.4.1 Filter Name

Select the name of each **FILTER [FILTER]** (see Table 19-5) you wish to use.

Table 19-5 Filters Available for MIRI Coronagraphic Photometric Calibrations

|  |  |  |  |
| --- | --- | --- | --- |
| Filter | Central Wavelength  (m) | Filter Bandpass Δ (m) | Maximum Number of Integrations |
| F1000W | 10.0 | 2.0 | TBD |
| F1500W | 15.0 | 3.0 | TBD |
| F560W | 5.6 | 1.2 | TBD |
| F2300C | 23.0 | 4.6 | TBD |
| F1550C | 15.5 | 0.8 | TBD |
| F1140C | 11.4 | 0.6 | TBD |
| F1065C | 10.7 | 0.5 | TBD |
| FND |  |  | TBD |

When multiple filters are selected and **PATTERN SIZE = DEFAULT**, you should list the filters in order by default pattern size to avoid unnecessary additional visits.

#### 19.7.4.2 Readout Pattern

**READOUT PATTERN [READOUT PATTERN] = SLOW [MIR0254], FAST [MIR0255]**

This field specifies the readout pattern to be used to obtain the data. **FAST** is used for bright targets and long wavelength imaging and **SLOW** is used for faint targets and deep imaging.

#### 19.7.4.3 Number of Groups

**NUMBER OF GROUPS [NGROUPS]** specifies the number of groups in an integration **[MIR0256]**.

#### 19.7.4.4 Number of Integrations

**NUMBER OF INTEGRATIONS [NINTS]** field specifies the number of times the integration is repeated **[MIR0257]**.