# Chapter 29

**NIRCam Engineering**

**In this chapter…**

## 29.1Introduction

The NIRCam Engineering templates are used for calibration and engineering activities for the NIRCam detectors. These operations may be to obtain darks, internal flat fields, exercise the filter and pupil wheels, or to perform focus checks and adjustments. The parameters described in this section are used to specify the Observations for NIRCam Engineering. More complete descriptions of the detector readout parameters, filters, detector characteristics, etc. are available in the NIRCam Instrument Handbook.

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

The NIRCam Engineering templates [NCM0153] consists of the following parameters:

| Field | Details | Values | Notes | |
| --- | --- | --- | --- | --- |
| **Dark** [NCM0154] | | | | |
| Module [NCM0155] | select Module | choose from list [NCM0156] |  | |
| Subarray [NCM0157] | select Subarray | choose from list [NCM0158] | See Table 16-1 | |
| Number of Exposures [NCM0159] | specify number of times to repeat exposure | number [NCM0160] |  | |
| Number of Groups [NCM0161] | specify number of groups | number [NCM0162] |  | |
| Number of Integrations [NCM0163] | specify number of integrations | number [NCM0164] |  | |
| Readout Pattern  [NCM0165] | select readout pattern | choose from list [NCM0166] | See Table 16-2 | |
| **Wheel Exercise** [NCM0177] | | | | |
| Mechanism Type [NCM0178] | specify Mechanism type | choose Filter/Pupil [NCM0179] | |  |
| Wheel [NCM0180] | specify Wheel | choose from list [NCM0181] | |  |
| Number of Rotations [NCM0182] | specify number of integrations | Number (1-6) [NCM0183] | |  |
| **Focus** [NCM0184] | | | | |
| Target Name [NCM0185\ | select Target Name | choose from list [NCM0186] | from Target list | |
| Module [NCM0187] | select Module | choose A or B [NCM0188] |  | |
| Filter  [NCM0190] | select Filter | choose from list [NCM0191] | See Table 16-3 and Table 16-4 | |
| Pupil [NCM0192] | select Pupil | choose from list [NCM0193] | See Table 16-5 and Table 16-6 | |
| Number of Groups [NCM0194] | specify number of groups | number [NCM0195] |  | |
| Number of Integrations [NCM0196] | specify number of integrations | number [NCM0197] |  | |
| Readout Pattern [NCM0198] | select readout pattern | choose from list [NCM0199] | See Table 16-2 | |
| Linear Actuators:  Starting position [NCM0200] | specify starting position of actuators in steps | number [NCM0201] |  | |
| Starting position [NCM0202] | specify starting position of actuators in sensor units | number [NCM0203] |  | |
| Starting motor phases [NCM0204] | specify starting motor phases of  actuators | number [NCM0205] |  | |
| Absolute positions [NCM0206] | specify array of positions for each  actuator | array of 1-10 positions [NCM0207] |  | |
| Return to Start [NCM0208] | select Return to Start mode | choose Yes or No [NCM0209] |  | |
| **IPR Imaging** [NCM0167] | | | | |
| Target Name [NCM0168] | select Target Name | choose from list [NCM0169] | from Target list | |
| Module [NCM0171] | select Module | choose from list [NCM0172] |  | |
| LED Lamp [NCM0173] | Select LED Lamp | choose from list [NCM0174] |  | |
| **PIL Imaging** [NCM0175] | | | | |
| Target Name [NCM0176] | select Target Name | choose from list [NCM0113] | from Target list | |
| Module [NCM0114] | select Module | choose A or B [NCM0142] |  | |
| Filter  [NCM0143] | select Filter | choose from list [NCM0144] |  | |
| Number of Groups [NCM0145] | specify number of groups | number [NCM0146] |  | |
| Number of Integrations [NCM0147] | specify number of integrations | number [NCM0148] |  | |
| Readout Pattern  [NCM0149] | select readout pattern | choose from list [NCM0150] |  | |
| **External Flat** [NCM0531] | | | | |
| Pointing Type [NCM0532] | select the type of pointing | Choose PRIME or PARALLEL [NCM0533] |  | |
| Target Name [NCM0534] | select Target Name | choose from list [NCM0535] | from Target list | |
| Primary Dither Type [NCM0536] | select Dither Type | choose from list [NCM0537] | See Table 29-9 | |
| Primary Dithers [NCM0538] | select number of steps | choose from list [NCM0539] |  | |
| Camera [NCM0540] | select SCA for INTRASCA | SHORT, LONG [NCM0541] |  | |
| Dither Size [NCM0542] | select dither size for INTRASCA | SMALL, MEDIUM, LARGE  [NCM0543] | See Table 29-11 | |
| Subpixel Positions [NCM0544] | select subpixel positions | 1, 2, 3 … 63, 64 [NCM0545] |  | |
| Module [NCM0546] | select Module | choose A, B, or All [NCM0547] |  | |
| Subarray [NCM0548] | select Subarray | choose from list [NCM0549] |  | |
| Filter [NCM0550] | select filter name | choose from list [NCM0551] | See Table 29-3 and Table 29-4 | |
| Pupil [NCM0552] | select pupil name | choose from list [NCM0553] | See Table 29-5 and Table 29-6 | |
| Readout Pattern [NCM0554] | select readout pattern | choose from list [NCM0555] |  | |
| Number of Groups [NCM0556] | specify number of groups | Number [NCM0557] | See Table 29-7 | |
| Number of Integrations [NCM0558] | specify number of integrations | Number [NCM0559] | See Table 29-7 | |

## 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 on other Sis [NCM0211].

### Module

MODULE [MODULE] = A [NCM0212], B [NCM0213], ALL [NCM0214], **A1** [NCM0245]**, A2** [NCM0240]**, A3** [NCM0246]**, A4** [NCM0241]**, ALONG** [NCM0243]**, B1** [NCM0247]**, B2** [NCM0258]**, B3** [NCM0248]**, B4** [NCM0249]**, BLONG** [NCM0257]

This parameter specifies the module that is to be used. The modules are defined as follows:

|  |  |
| --- | --- |
| Module | Definition |
| A | All short and long wavelength detectors in Module A |
| B | All short and long wavelength detectors in Module B |
| ALL | All detectors in Module A and then all detectors in Module B |
| A1-A4 | SCA Ax in Module A, where x = 1-4 |
| ALONG | The long wavelength detector in Module A |
| B1-B4 | SCA Bx in Module B, where x = 1-4 |
| BLONG | The long wavelength detector in Module B |

See the NIRCam Instrument Handbook for more details.

### Subarray

#### SUBARRAY [SUBARRAY] = SUB160, SUB320, SUB640, FULL

This value specifies the region of the SCA that is to be read out. Subarrays other than **FULL** can only be specified if **MODULE** is B [NCM0xxx]. See Table 29-1 for details.

Table 29-1 Readout Regions for NIRCam Darks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Subarray | Rows | Columns | Light Sensitive Columns |
| [NCM0215] | FULL | 2048 | 2048 | TBD |
| [NCM0348] | SUB160 | 160 | 160 | All |
| [NCM0219] | SUB320 | 320 | 320 | All |
| [NCM0220] | SUB640 | 640 | 640 | All |

For developers: users can specify one or more combinations of the parameters below for DARKs. [NCM0221]

### Number of Exposures

**NUMBER OF EXPOSURES [NEXP]** specifies the number of times the dark exposure is to be repeated [NCM0438].

### Exposure Duration

The following parameters define a dark exposure.

#### Readout Pattern

#### READOUT PATTERN [READOUT PATTERN] = DEEP8, DEEP2, MEDIUM8, MEDIUM2, SHALLOW4, SHALLOW2, BRIGHT2, BRIGHT1, RAPID

This field specifies the readout pattern to be used to obtain the data. Note that for **MODULE**=**ALL**, **READOUT PATTERN**=**RAPID** or **BRIGHT2**, and **SUBARRAY**=**FULL**,

**NGROUPS** must be less than or equal to 4 and **NINTS** must be 1. See **Table 29-2** for when to use the various readout patterns.

#### Number of Groups

**NUMBER OF GROUPS [NGROUPS]** specifies the number of groups in an integration [NCM0439] (see Table 29-2 for the maximum values).

**.**

#### Number of Integrations

**NUMBER OF INTEGRATIONS [NINTS]** field specifies the number of times the integration is repeated [NCM0440] (see Table 29-2 for the maximum values).

Table 29-2 Maximum Number of Integrations and Groups for Darks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Readout Pattern | Maximum Integrations | | Maximum Groups | Usage |
| RAPID  (MODULE=ALL) | 10  1 | 50  4 | | Fastest mode possible |
| BRIGHT1 | 10 | 10 | | bright objects; high BKG/wide filters |
| BRIGHT2  (MODULE=ALL) | 10  1 | 10  4 | | bright objects; high BKG/wide filters |
| SHALLOW2 | 10 | 10 | | shallow surveys/bright objects; high BKG/ wide filters |
| SHALLOW4 | 10 | 10 | | shallow surveys/bright objects; moderate BKG/narrow or medium filters |
| MEDIUM2 | 10 | 20 | | medium/shallow surveys; moderate BKG/wide filters |
| MEDIUM8 | 10 | 20 | | medium/shallow surveys; low BKG/narrow filters |
| DEEP2 | 10 | 20 | | deep surveys; moderate BKG/wide filters |
| DEEP8 | 10 | 20 | | deep surveys; low BKG/narrow filters |

Table 29-2 Maximum Number of Integrations and Groups for Darks

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Readout Pattern | Maximum Integrations | | Maximum Groups | Legal Min/Max | Illegal Min/Max |
| RAPID  (MODULE=ALL) | 10  1 | 50  4 | | [NCM0222]  [NCM0230] | [NCM0234]  [NCM0234] |
| BRIGHT1 | 10 | 10 | | [NCM0223] | [NCM0231] |
| BRIGHT2  (MODULE=ALL) | 10  1 | 10  4 | | [NCM0224]  [NCM0239] | [NCM0232]  [NCM0346] |
| SHALLOW2 | 10 | 10 | | [NCM0225] | [NCM0339] |
| SHALLOW4 | 10 | 10 | | [NCM0226] | [NCM0235] |
| MEDIUM2 | 10 | 20 | | [NCM0227] | [NCM0236] |
| MEDIUM8 | 10 | 20 | | [NCM0228] | [NCM0237] |
| DEEP2 | 10 | 20 | | [NCM0229] | [NCM0238] |
| DEEP8 | 10 | 20 | | [NCM0244] | [NCM0242] |

## Wheel Exercise

These parameters are required to rotate the specified wheel 360o. Note that this type of observation cannot be obtained as a parallel to normal science observations, but can be in parallel with slews.

### Mechanism Type

#### MECHANISM TYPE [MECH TYPE] = FILTER [NCM0260], PUPIL [NCM0261]

This parameter specifies the mechanism type to be exercised.

### Wheel

#### WHEEL [WHEELSLIST] = SHORTA [NCM0262], SHORTB [NCM0263], LONGA [NCM0264], LONGB [NCM0265], ALL [NCM0266]

This parameter specifies the wheel(s) to be exercised. You may specify one wheel [NCM0267], more than one wheel (up to all four) [NCM0268] or **ALL** [NCM0269]. Specifying a list of two to four wheels will exercise those wheels serially and in the order specified. Specifying **ALL** exercises all four wheels in parallel.

### Number of Rotations

**NUMBER OF ROTATIONS [NROTATIONS]** [NCM0312] specifies the number of time to rotate the selected wheel(s) (between 1 and 6, inclusive).

## Focus

These parameters are required to obtain Focus observations. An exposure with these parameters will be taken before any position change and then after each position change requested. Note that this type of observation can be obtained as a parallel to normal science observations.

At the present time, the NIRCam science team has insisted that the NIRCam focus template should include user inputs to define the starting focus position (in both steps and sensor units). It seems possible that this might cause confusion and prevent users from running a focus set. At the present time, the focus template is defined in the manner requested by the NIRCam team, but if this proves problematic then changes to this template definition might be warranted in the future.

### Target Name

Select the **TARGET NAME** **[TBD]** from the list of targets previously entered (see Section 5.8). [NCM0075]

### Module

#### MODULE [MODULE] = A [NCM0076], B [NCM0151]

This parameter specifies the module that is to be used.

### Filter

Select the name of the **FILTER [FILTLONG, FILTSHORT]** pair (seeTable 29-3 and Table 29-4) you wish to use (one for the Short Wavelength and one for the Long Wavelength cameras). You may select a filter pair [NCM0340], a single filter [NCM0341], or no filters [NCM0342].

Table 29-3 Filters Available for NIRCam Short Wavelength Camera Focus Observations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Filter | Center Wavelength 0 (m) | Filter Bandpass (m) | Comment |  |
| F070W | 0.70 | 0.175 |  | [NCM0313] |
| F090W | 0.90 | 0.225 |  | [NCM0314] |
| F115W | 1.15 | 0.288 |  | [NCM0315] |
| F150W | 1.50 | 0.375 |  | [NCM0316] |
| F150W2 | 1.50 | 1.000 |  | [NCM0317] |
| F200W | 2.00 | 0.500 |  | [NCM0318] |
| F140M | 1.14 | 0.140 |  | [NCM0319] |
| F182M | 1.82 | 0.221 |  | [NCM0320] |
| F210M | 2.10 | 0.210 |  | [NCM0321] |
| F187N | 1.87 | 0.019 | Pα | [NCM0322] |
| F212N | 2.12 | 0.021 | H2 | [NCM0323] |
| WLP4 |  |  | Weak Lens, +4 waves defocus | [NCM0324] |

Table 29-4 Filters Available for NIRCam Long Wavelength Camera Focus Observations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Filter | Center Wavelength 0 (m) | Filter Bandpass (m) | Comment |  |
| F277W | 2.77 | 0.693 |  | [NCM0325] |
| F322W2 | 3.22 | 1.610 |  | [NCM0326] |
| F356W | 3.56 | 0.890 |  | [NCM0327] |
| F444W | 4.44 | 1.110 |  | [NCM0328] |
| F250M | 2.50 | 0.167 |  | [NCM0329] |
| F300M | 3.00 | 0.300 |  | [NCM0330] |
| F335M | 3.35 | 0.335 |  | [NCM0331] |
| F360M | 3.60 | 0.360 |  | [NCM0332] |
| F410M | 4.10 | 0.410 |  | [NCM0333] |
| F430M | 4.30 | 0.200 |  | [NCM0334] |
| F460M | 4.60 | 0.200 |  | [NCM0335] |
| F480M | 4.80 | 0.400 |  | [NCM0336] |

### Pupil

Select the name of the **PUPIL [PUPILLONG,** **PUPILSHORT]** pair (see Table 29-5 and Table 29-6) you wish to use (one for the Short Wavelength and one for the Long Wavelength cameras).

You may select a pupil pair [NCM0343], a single pupil [NCM0344], or no pupils [NCM0345].

Table 29-5 Pupils Available for NIRCam Short Wavelength Camera Internal Flats

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Pupil | Center Wavelength 0 (m) | Filter Bandpass (m) | Comment |
| [NCM0270] | CLEAR |  |  | Imaging pupil |
| [NCM0271] | MASKRND |  |  | Round mask 1 |
| [NCM0272] | MASKBAR |  |  | Bar mask2 |
| [NCM0274] | F162M | 1.62 | 0.151 | CO (6-3) |
| [NCM0275] | F164N | 1.64 | 0.016 | Fe II |
| [NCM0277] | GDHS0 |  |  | Dispersed Hartman Sensor 0 degrees |
| [NCM0278] | GDHS60 |  |  | Dispersed Hartman Sensor 60 degrees |
| [NCM0279] | PINHOLES |  |  |  |
| [NCM0280] | WL1 |  |  | Weak Lens (-8 waves defocus) |
| [NCM0281] | WL2 |  |  | Weak lens (+8 waves defocus) |

Table 29-6 Pupils Available for NIRCam Long Wavelength Camera Internal Flats

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Pupil | Center Wavelength 0 (m) | Filter Bandpass (m) | Comment |
| [NCM0282] | CLEAR |  |  | Imaging pupil |
| [NCM0283] | MASKRND |  |  | Round mask 1 |
| [NCM0284] | MASKBAR |  |  | Bar mask2 |
| [NCM0286] | F323N | 3.23 | 0.032 | H2 |
| [NCM0287] | F405N | 4.05 | 0.041 | Brα |
| [NCM0289] | F466N | 4.66 | 0.047 |  |
| [NCM0290] | F470N | 4.70 | 0.047 |  |
| [NCM0291] | GRISMR |  |  | Spectrum parallel to detector rows |
| [NCM0292] | GRISMC |  |  | Spectrum parallel to detector columns |
| [NCM0293] | PINHOLES |  |  |  |

### Exposure Duration

The following parameters define a focus exposure.

#### Readout Pattern

#### READOUT PATTERN [READOUT PATTERN] = DEEP8 [NCM0294], DEEP2 [NCM0295], MEDIUM8 [NCM0296], MEDIUM [NCM0297], SHALLOW4 [NCM0298], SHALLOW2 [NCM0299], BRIGHT2 [NCM0300], BRIGHT1 [NCM0301], RAPID [NCM0302]

This field specifies the readout pattern to be used to obtain the data; see Table 29-7 for when to use the various readout patterns.

#### Number of Groups

**NUMBER OF GROUPS [NGROUPS]** specifies the number of groups in an integration [NCM0436] (see Table 29-7 for the maximum values).

#### Number of Integrations

**NUMBER OF INTEGRATIONS [NINTS]** field specifies the number of times the integration is repeated [NCM0437] (see Table 29-7 for the maximum values)..

Table 29-7 Maximum Number of Integrations and Groups for Focus and PIL Imaging

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Readout Pattern | Maximum Integrations | | Maximum Groups | Usage |
| RAPID | 10 | 10 | | Fastest mode possible |
| BRIGHT1 | 10 | 10 | | bright objects; high BKG/wide filters |
| BRIGHT2 | 10 | 10 | | bright objects; high BKG/wide filters |
| SHALLOW2 | 10 | 10 | | shallow surveys/bright objects; high BKG/ wide filters |
| SHALLOW4 | 10 | 10 | | shallow surveys/bright objects; moderate BKG/narrow or medium filters |
| MEDIUM2 | 10 | 10 | | medium/shallow surveys; moderate BKG/wide filters |
| MEDIUM8 | 10 | 10 | | medium/shallow surveys; low BKG/narrow filters |
| DEEP2 | 10 | 20 | | deep surveys; moderate BKG/wide filters |
| DEEP8 | 10 | 20 | | deep surveys; low BKG/narrow filters |

Table 29-7 Maximum Number of Integrations and Groups for Focus and PIL Imaging

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Readout Pattern | Max  Int | Max Grp | Legal Focus  Min/Max | Illegal Focus  Min/Max | Legal PIL  Min/Max | Illegal PIL  Min/Max |
| RAPID | 10 | 10 | [NCM0449] | [NCM0458] | [NCM0499] | [NCM0508] |
| BRIGHT1 | 10 | 10 | [NCM0450] | [NCM0459] | [NCM0500] | [NCM0509] |
| BRIGHT2 | 10 | 10 | [NCM0451] | [NCM0460] | [NCM0501] | [NCM0510] |
| SHALLOW2 | 10 | 10 | [NCM0452] | [NCM0461] | [NCM0502] | [NCM0511] |
| SHALLOW4 | 10 | 10 | [NCM0453] | [NCM0462] | [NCM0503] | [NCM0512] |
| MEDIUM2 | 10 | 10 | [NCM0454] | [NCM0463] | [NCM0504] | [NCM0513] |
| MEDIUM8 | 10 | 10 | [NCM0455] | [NCM0464] | [NCM0505] | [NCM0514] |
| DEEP2 | 10 | 20 | [NCM0456] | [NCM0465] | [NCM0506] | [NCM0515] |
| DEEP8 | 10 | 20 | [NCM0457] | [NCM0466] | [NCM0507] | [NCM0516] |

### Linear Actuators

The Linear Actuators are the devices that control the image focus.

#### Starting Position in Steps

This parameter specifies the **STARTING POSITION [LASTEPSLIST]** of each of the 3 actuators in Steps (-11900 to +11900). [NCM0303]

#### Starting Position in Sensor Units

This parameter specifies the **STARTING POSITION [LASUNITSLIST]** of each of the 3 actuators in Sensor units (-32767 to +32767). [NCM0304]

#### Starting Motor Phases

This parameter specifies the **STARTING MOTOR PHASE [LAPHASELIST]** of each of the 3 actuators (1-6). [NCM0305]

Note for developers: the 3 values above are all integers, with the first 2 requiring a sign.

#### Absolute Positions

The **ABSOLUTE POSITION [LA1LIST, LA2LIST, LA3LIST]** parameter specifies an array of 1 to 10 sets of positions (each composed of a value for each of the three actuators). Individual actuator values can range from -11900 to +11900 [NCM0306]. If only one position is listed the focus will be adjusted to that position and stay there. If multiple positions are listed they will be executed in the exact order specified [NCM0307] and the option to return to the original position is available (next parameter) [NCM0308].

#### Return to Start

**RETURN TO START [RETURN TO START]** **= YES** [NCM0309] **(default)** [NCM0310]**, NO** [NCM0311]

If multiple positions have been listed, this parameter is available to request if the Actuator should be returned to its original position (**YES**) or left at the final position (**NO**). If one position has been requested, this parameter will default to NO (focus mechanism is left at the specified position).

For the developers: Basically, what we need is a table like the following:

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Actuator 1 | Actuator 2 | Actuator 3 |
| LASTEPSLIST | value | value | value |
| LASUNITSLIST | value | value | value |
| LAPHASELIST | value | value | value |
| Position 1 | LA1value | LA2value | LA3value |
| Position 2 | LA1value | LA2value | LA3value |
| … | … | … | … |
| Position 10 | LA1value | LA2value | LA3value |

Also, if one actuator position is specified, the parameter should not be set.

## IPR Imaging

These parameters are required to obtain observations with the Internal Phase Retrieval (IPR) wedges while flashing the LED lamps. The data will be analyzed to measure the wavefront error internal to NIRCam, and to track that WFE over time. Calibration measurements will be taken based on the combination of Module and LED Lamp.

Note that this type of observation must be executed as a prime, as it requires an external pointing. Therefore the special requirement **PARALLEL** is not allowed [NCM0xxx].

### Module

**MODULE [MODULE] = A** [NCM0216]**, B** [NCM0217]**, ALL** [NCM0218]**, ASHORT** [NCM0347]**, ALONG** [NCM0443]**, BSHORT** [NCM0444]**, BLONG** [NCM0445]

This parameter specifies the module that is to be used. The modules are defined as follows:

|  |  |
| --- | --- |
| Module | Definition |
| A | All short and long wavelength detectors in Module A |
| B | All short and long wavelength detectors in Module B |
| ALL | All detectors in Module A and then all detectors in Module B |
| ASHORT | All 4 SCAs in the short wavelength detector for Module A |
| ALONG | The long wavelength detector in Module A |
| BSHORT | All 4 SCAs in the short wavelength detector for Module B |
| BLONG | The long wavelength detector in Module B |

See the NIRCam Instrument Handbook for more details.

### LED Lamp

**LED LAMP [LEDLAMP] = PRIME** [NCM0446]**, REDUNDANT** [NCM0447]**, BOTH** [NCM0448]

This parameter specifies the LED lamp that is to be used.

## PIL Imaging

## 

These parameters are required to obtain observations with the Pupil Imaging Lens (PIL) in the short wavelength beam of Module A or Module B. Note that this type of observation must be executed as a prime, as it requires an external pointing. Therefore the special requirement PARALLEL is not allowed [NCM0466].

### Target Name

Select the **TARGET NAME** **[TBD]** from the list of targets previously entered (see Section 5.8) [NCM0467].

### Module

**MODULE [MODULE] = A** [NCM0468]**, B** [NCM0469]

This parameter specifies the module that is to be used.

### Filters

Select the name of each short wavelength filter [**FILTSHORT**] you wish to use (see Table 29-8). There is no limit on the number of filters [NCM0470], but there is a limit of 70 minutes (TBD) for total exposure time in PIL observations [NCM0471].

Table 29-8 Filters Available for PIL Imaging

|  |  |  |  |
| --- | --- | --- | --- |
| Filters |  | Filters |  |
| F187N | [NCM0472] | WLM8+F150W | [NCM0517] |
| F212N | [NCM0473] | WLM8+F200W | [NCM0518] |
| F150W | [NCM0474] | WLM8+F150W2 | [NCM0519] |
| F200W | [NCM0475] | MASKRND+F150W | [NCM0520] |
| F140M | [NCM0476] | MASKRND+F200W | [NCM0521] |
| WLP4 | [NCM0477] | MASKRND+F150W2 | [NCM0522] |
| PINHOLES+F150W | [NCM0478] | MASKBAR+F150W | [NCM0523] |
| PINHOLES+F200W | [NCM0479] | MASKBAR+F200W | [NCM0524] |
| GDHS0+F140M | [NCM0480] | MASKBAR+F150W2 | [NCM0525] |
| GDHS0+F150W2 | [NCM0481] | MASKIPR+F150W | [NCM0526] |
| GDHS60+F140M | [NCM0482] | MASKIPR+F200W | [NCM0527] |
| GDHS60+F150W2 | [NCM0483] | MASKIPR+F150W2 | [NCM0528] |
| WLP8+F150W | [NCM0484] | F162M+F150W2 | [NCM0529] |
| WLP8+F200W | [NCM0485] | F164N+F150W2 | [NCM0530] |
| WLP8+F150W2 | [NCM0486] |  |  |

### Exposure Duration

For each filter chosen you will also give the exposure duration parameters (Readout Pattern, Number of Groups, and Number of Integrations) [NCM0487]

.

#### Readout Pattern

**READOUT PATTERN [READOUT PATTERN] = RAPID** [NCM0496]**, BRIGHT1** [NCM0495]**, BRIGHT2** [NCM0494]**, SHALLOW2** [NCM0493]**, SHALLOW4** [NCM0492]**, MEDIUM2** [NCM0491]**, MEDIUM8** [NCM0490]**, DEEP2** [NCM0489]**, DEEP8** [NCM0488]

This field specifies the readout pattern to be used to obtain the data. See Table 29-7 for when to use the various readout patterns.

#### Number of Groups

**NUMBER OF GROUPS** [NGROUPS] specifies the number of groups in an integration (see Table 29-7 for the maximum values) [NCM0497].

#### Number of Integrations

**NUMBER OF INTEGRATIONS** [NINTS] specifies the number of times the integration is repeated (see Table 29-7 for the maximum values) [NCM0498].

## External Flat

The NIRCam External Flats template is to be used for all Flat-field observations using external targets. Note that this type of operation can be obtained as prime [NCM0560] or as a parallel to normal science observations [NCM0561].

### Pointing Type

**POINTING TYPE [TBR] = PARALLEL** [NCM0562] **(default)** [NCM0563]**, PRIME** [NCM0564]

This parameter allows the user to control whether the data will be obtained in parallel like other calibrations, or as a primary observation like regular science.

Note for developers: If **PARALLEL**, the target will be set to **NONE** (and not changeable) [NCM0565]and **PARALLEL** special requirement will be added [NCM0566]. If **PRIME**, the target will be changed from **NONE** to **NONE SELECTED** [NCM0567]so the user will be prompted to select a target. If **POINTING TYPE = PARALLEL**, set **PRIMARY DITHER TYPE** to **NONE** [NCM0568].

Note for developers: This field is not saved directly into the database, but instead should cause the **PARALLEL** special requirement to be added to template when **PARALLEL** is chosen.

### Target Name

Select the **TARGET NAME** [**TBD**] from the list of targets previously entered (see Section 5.4) A target is only allowed if **POINTING\_TYPE = PRIME** [NCM0569].

### Dither Patterns

The following parameters define the dither patterns for NIRCam External Flats. If the **POINTING TYPE** is **PRIME**, the user must select one of the following Dither Patterns [NCM0570].

* + - 1. **Primary Dither Type**

**PRIMARY DITHER TYPE [DITHER\_FOV]** **= NONE** [NCM0571]**, FULL** [NCM0572]**, INTRAMODULE** [NCM0573]**, INTRASCA** [NCM0574]

Note for developers: PRIMARY DITHER TYPE should be a required field [NCM0575], and there should be no default value (i.e. do not make NONE the default) [NCM0576].

This parameter specifies the type of primary dither pattern (see Table 0‑1).

Table 29-9 Primary Dither Type Available for NIRCam External Flats

|  |  |
| --- | --- |
| Primary Dither Type | Description |
| NONE | No dithering |
| FULL | Covers the 40" gap between modules |
| INTRAMODULE | Covers the 5" gaps between SCAs, but not the module gap |
| INTRASCA | Moves a target around a single SCA |

* + - * 1. **None**

This value indicates no dithering will be performed.

* + - * 1. **Full**

The following parameter is needed to specify the **FULL** dither [NCM0577].

***Primary Dithers***

**PRIMARY DITHERS [PRIMARY\_DITHERS]** **= 2, 3, 6, 9, 3TIGHT, 15, 21, 27, 36, 45**

This parameter indicates the number of steps in the primary dither (see Table 29-10).

**Table 29-10 PRIMARY DITHERS available for PRIMARY DITHER TYPE=FULL**

|  |  |  |
| --- | --- | --- |
| PRIMARY DITHERS |  | Description |
| 2 | [NCM0578] | 2-point pattern for NIRSpec pre-imaging |
| 3 | [NCM0579] | 3-point pattern that maximizes inner area of 2× coverage |
| 6 | [NCM0580] | 6-point pattern that maximizes area of 4× coverage  (minimum 3×-coverage everywhere) |
| 9 | [NCM0581] | 9-point pattern that maximizes area of 6× coverage  (minimum 5×-coverage everywhere) |
| 3TIGHT | [NCM0582] | 3-point pattern that maximizes depth of 3× coverage |
| 15 | [NCM0583] | Specific patterns to take optimally flat coverage |
| 21 | [NCM0584] |
| 27 | [NCM0585] |
| 36 | [NCM0586] |
| 45 | [NCM0587] |

* + - * 1. **Intramodule**

The following parameter is needed to specify the **INTRAMODULE** dither [NCM0588].

***Primary Dithers***

**PRIMARY DITHERS [PRIMARY\_DITHERS]** **= 2** [NCM0589]**, 3, 4, 5, 6, 7, 8** [NCM0590]**, 9, 10, 11, 12, 13, 14, 15, 16** [NCM0591]

This parameter specifies the number of primary dither points covering the 40" module gap.

* + - * 1. **Intrasca**

The following parameters are needed to specify the **INTRASCA** dither [NCM0592].

***Camera***

**CAMERA [CAMERA] = SHORT** [NCM0593]**, LONG** [NCM0594]

This parameter indicates the SCA that will have optimized coverage.

***Dither Size***

**DITHER SIZE [DITHER\_SIZE] = SMALL** [NCM0595]**, MEDIUM** [NCM0596]**, LARGE** [NCM0597]

This parameter specifies the size of the dither in arcseconds. The definition of **DITHER SIZE** depends on the Camera as shown in Table 29-11.

**Table 29-11** **Recommended DITHER SIZE based on object size and CAMERA**

|  |  |  |
| --- | --- | --- |
| Camera | Object Size (diameter) | Dither Size |
| Short | <10” | 10” (LARGE) |
|  | 10” – 30” | 1” (MEDIUM) |
|  | 30” – 50” | 0.1” (SMALL) |
| Long | <20” | 20” (LARGE) |
|  | 20” – 60” | 2” (MEDIUM) |
|  | 60” – 100” | 0.2” (SMALL) |

***Primary Dithers***

**PRIMARY DITHERS [PRIMARY\_DITHERS]** **= 2** [NCM0598]**, 3, 4, 5, 6, 7, 8, 9, 10** [NCM0599]**, … 23, 24, 25** [NCM0600]

This parameter specifies the number of primary dither points.

* + - 1. **Subpixel Positions**

**SUBPIXEL POSITIONS [SUBPIXEL\_POSITIONS] = 1** [NCM0601]**, 2, 3, 4, 5, 6** [NCM0602]**… 62, 63, 64** [NCM0603]

This parameter specifies the secondary dither points used for every primary dither point and is allowed for all DITHER FIELD OF VIEW values, including **NONE** [NCM0604].

Note for developers: see Appendix F2 for dithering details.

### Module

**MODULE [MODULE] = A** [NCM0605]**, B** [NCM0606]**, ALL** [NCM0607]

This parameter specifies the module to be used to obtain the data.

### Subarray

**SUBARRAY [SUBARRAY] = FULL** [NCM0608]**, SUB640** [NCM0609]**, SUB320** [NCM0610]**, SUB160** [NCM0611]**, SUB400P** [NCM0612]**, SUB160P** [NCM0613]**, and SUB64P** [NCM0614]

This parameter specifies the region of the SCA that is to be read out. Subarrays other than **FULL** are only allowed if **MODULE** = **B** [NCM0615]. If selecting **SUB400P**, **SUB160P**, or **SUB64P**, only one short wavelength SCA and the long wavelength SCA will be read out.

### 29.7.6 Filters

Select the name of each **FILTER [FILTLONG, FILTSHORT]** pair (see Table 29-3 and Table 29-4) that you wish to use [NCM0616]. If **POINTING TYPE** is specified as **PARALLEL**, only one long and one short filter may be selected [NCM0617].

### Pupils

Select the name of each pupil [**PUPILLONG, PUPILSHORT**] pair (see Table 29-5 and Table 29-6) that you wish to use [NCM0618]. If **POINTING TYPE** is specified as **PARALLEL**, only one long and one short pupil may be selected [NCM0619].

Note for Developers: The following tables summarize the allowed Filter Wheel + Pupil Wheel element combinations in the NIRCam Short Wavelength and Long Wavelength channels, respectively. Checks on the validity of these combinations should be implemented in the APT template. Table elements “ok” can be selected [NCM0620], elements “W” will generate a warning [NCM0621], and elements “E” will generate an error; [NCM0622] the PAPPA and Flat/Dark elements (“D”) are disallowed and cannot be selected by the user [NCM0623] since no (or no significant) external light will reach the detectors if the Flat/Dark (PAPPA) element is in the beam.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Short wavelength channel | | Pupil wheel (grouped by function) | | | | | | | | | | | |
| Clear | Flatfield/Dark | Coronagraph 1 (round) | Coronagraph 2 (bar) | F164N | F162M | PINHOLES | WL 1 (+8) | WL 2 (-8) | GDHS0 | GDHS60 | MASKIPR |
| Filter Wheel | F070W [NCM0637] | ok | D | E | E | E | E | D | W | W | E | E | W |
| F090W [NCM0638] | ok | D | E | E | E | E | D | W | W | E | E | W |
| F115W [NCM0639] | ok | D | E | E | E | E | D | W | W | W | W | W |
| F150W [NCM0640] | ok | D | E | E | ok | E | D | W | W | W | W | W |
| F200W [NCM0641] | ok | D | ok | ok | E | E | D | W | W | W | W | W |
| F212N [NCM0642] | ok | D | ok | ok | E | E | D | ok | ok | W | W | ok |
| WLP4  [NCM0643] | ok | D | E | E | E | E | D | ok | ok | E | E | ok |
| F187N  [NCM0644] | ok | D | ok | ok | E | E | D | ok | ok | W | W | W |
| F210M  [NCM0645] | ok | D | ok | ok | E | E | D | W | W | W | W | W |
| F182M  [NCM0646] | ok | D | ok | ok | E | E | D | W | W | W | W | W |
| F140M  [NCM0647] | ok | D | E | E | E | E | D | W | W | ok | ok | W |
| F150W2  [NCM0648] | ok | D | E | E | ok | ok | D | W | W | ok | ok | W |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Long wavelength channel | | Pupil wheel (grouped by function) | | | | | | | | | | | |
| Clear | Flat/Dark | Coronagraph 1 (round) | Coronagraph 2 (bar) | F323N | F405N | F466N | F470N | Outward Pinholes | GrismR (V2) | GrismC (V3) | MASKIPR |
| Filter Wheel | F277W [NCM0649] | ok | D | W | ok | E | E | E | E | D | ok | ok | W |
| F356W [NCM0650] | ok | D | ok | ok | ok | E | E | E | D | ok | ok | W |
| F444W [NCM0651] | ok | D | ok | ok | E | ok | ok | ok | D | ok | ok | W |
| F300M [NCM0652] | ok | D | ok | ok | E | E | E | E | D | W | W | W |
| F480M [NCM0653] | ok | D | E | ok | E | E | W | W | D | W | W | W |
| F410M [NCM0654] | ok | D | ok | ok | E | W | E | E | D | ok | ok | W |
| F360M [NCM0655] | ok | D | ok | ok | E | E | E | E | D | W | W | W |
| F430M [NCM0656] | ok | D | ok | ok | E | E | E | E | D | W | W | W |
| F460M [NCM0657] | ok | D | ok | ok | E | E | W | E | D | W | W | W |
| F250M [NCM0658] | ok | D | W | ok | E | E | E | E | D | W | W | W |
| F335M [NCM0659] | ok | D | ok | ok | W | E | E | E | D | W | W | W |
| F322W2 [NCM0660] | ok | D | W | W | ok | E | E | E | D | ok | ok | W |

### Readout Pattern

**READOUT PATTERN [READOUT PATTERN] = MEDIUM2** [NCM0624] **(default)** [NCM0625]**, RAPID** [NCM0626]**, BRIGHT1** [NCM0627]**, BRIGHT2** [NCM0628]**, SHALLOW2** [NCM0629]**, SHALLOW4** [NCM0630]**, MEDIUM8** [NCM0631]**, DEEP2** [NCM0632]**, DEEP8** [NCM0633]

This field specifies the readout pattern to be used to obtain the data. See Table 29-7 for when to use the various readout patterns.

### Number of Groups

**NUMBER OF GROUPS [NGROUPS]** specifies the number of groups in an integration (see Table 29-7 for the maximum values) [NCM0634]. The default value is 10 [NCM0635].

### Number of Integrations

**NUMBER OF INTEGRATIONS [NINTS]** field specifies the number of times the integration is repeated [NCM0636] (see Table 29-7 for the maximum values).