

NIRCam Coronagraphic Imaging APT Template

Instructions for designing JWST [NIRCam Coronagraphic Imaging](#) observations using [APT](#), the Astronomer's Proposal Tool.

Introduction

[Coronagraphic imaging](#) is one of five observing modes available with the [Near Infrared Camera \(NIRCam\)](#). NIRCam offers five [coronagraphic occulting masks](#) in the focal plane and two [Lyot stops](#) in the pupil plane. One Lyot stop is used with the round coronagraphic masks, and the other Lyot stop is used with the bar-shaped coronagraphic masks. NIRCam's three round coronagraphic masks, **MASK210R**, **MASK335R**, and **MASK430R**, have inner working angles IWA = 0.40", 0.63", and 0.81" (radius), corresponding to $6\lambda/D$ at 2.1, 3.35 and 4.1 μm . The two bar-shaped coronagraphic masks, **MASKSWB** and **MASKLWB**, are tapered, with IWA varying by a factor of three along their lengths. The half widths at half maximum (HWHM) at the bar end points for the short-wavelength (SW) occulter **MASKSWB** are 0.13" and 0.39", whereas for the long-wavelength (LW) occulter **MASKLWB** are 0.29" and 0.87".

The observer will have control over three primary parameters for NIRCam coronagraphic imaging:

1. [coronagraphic mask](#) + [filter](#) combination
2. [small grid-dithering](#) type
3. [detector read out pattern](#) and exposure time (via the number of groups and integrations).

Performing multiple coronagraphic observations enables [PSF subtraction](#) as described below in [PSF Reference Observations](#).

Allowed values are documented in the [NIRCam Coronagraphic Imaging Template parameters](#).

Step-by-Step APT instructions

Generic

The following parameters are generic to all templates, and are not discussed in this article: [Observation Number](#), [Observation Label](#), [Observations Comments](#), [Target Name](#), [ETC Workbook Calculation ID](#), [Mosaic Properties](#), and [Special Requirements](#).

Note: mosaics are not available for NIRCam coronagraphic imaging.

Module

NIRCam coronagraphic imaging is available only using **Module A**, with **Module B** as a back-up. This parameter is not user changeable.

Coronagraphic mask

The user specifies the **coronagraphic mask**, depending on the target-host separation, necessary contrast, and desired filter. Selection of the coronagraphic mask determines also the **Acq Filter** parameter and the Target Acquisition Subarray. The available coronagraphic masks are: **MASK210R**, **MASKSWB**, **MASK335R**, **MASK430R**, **MASKLWB**.

Target Acquisition parameters

Target Acquisition is required for coronagraphic imaging. This section specifies the **Target ACQ** and **Acq Exposure Time**.

Target ACQ

The user specifies the **Acq Target** and the **Acq Target Brightness**.

The **Acq Filter** is determined by the choice of the coronagraphic mask and it is not user changeable (**F210M** for the SW occulters **MASK210R** and **MASKSWB**, and **F335M** for the LW occulters **MASK335R**, **MASK430R**, and **MASKLWB**).

Acq Target

The selected **Acq Target** may be either the same as the science target or any other **target** defined in the APT file.

Acq Target Brightness

1. **FAINT**
2. **BRIGHT**

The user selects the **Acq Target Brightness** parameter as a function of the target magnitude in the **Acq Filter**. If **BRIGHT** is chosen, the target will be imaged through a neutral density (ND) square. **BRIGHT** should be used for targets with magnitudes brighter than approximately 8.2 mag (**F210M**) and 6.8 mag (**F335M**).

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 characteristic](#) parameters: **Acq Readout Pattern** and **Acq Groups per Integration**.

i Please consult the [Exposure Time Calculator \(ETC\)](#). We recommend a signal-to-noise ratio of 30 or higher to obtain a centroid accuracy of 0.1 pixel for the TA source. We also recommend not saturating any pixels.

Acq Readout Pattern

All nine NIRCcam readout patterns are available for the Target Acquisition: **RAPID**, **BRIGHT1**, **BRIGHT2**, **SHALLOW2**, **SHALLOW4**, **MEDIUM2**, **MEDIUM8**, **DEEP2**, **DEEP8**.

Acq Groups per Integration

Acq Groups/Int defines the number of groups during an integration. The user can select one of the following options: **3**, **5**, **9**, **17**, **33**, **65**.

Note that Target ACQ images are taken using the 128^2 (SW) or 64^2 (LW) subarray. For this reason, the number of groups per integration is not limited to 10 as in the Astrometric Confirmation Image and Science Exposure.

Acq Integrations/Exp, **Acq Total Integrations**, and **Acq Total Exposure Time** are not user changeable. For Target ACQ, **Acq Integrations/Exp** is always 1.

Astrometric confirmation image parameters

Obtain astrometric confirmation images?

If **Yes** is selected, confirmation images are taken. These are two identical, full frame exposures using the four SW SCAs (for the SW masks), or the one LW SCA (for the LW masks). Images are taken before and after the science exposures. The first one is taken before and the second taken after the pointing adjustment that moves the target from the target acquisition position to the location behind the selected coronagraphic mask. The filter for confirmation images is the same as the target acquisition filter in **Acq Filter**.

Conf. exposure time

The user configures the Astrometric Confirmation Image exposure time by setting the following parameters: **Conf. Readout Pattern**, **Conf. Groups/Int**, **Conf. Integrations/Exp**. The maximum number of groups per integration is 10. The resulting exposure time is displayed in **Conf. Total Exposure Time**. **Conf. Total Dithers** and **Conf. Total Integration** are not user changeable. For the Astrometric Confirmation Image **Conf. Total Dithers** is always 1.

Science exposures

Subarray

NIRCam coronagraphic imaging supports observations using the full-frame or a [subarray](#) on a single detector.

Subarrays reduce data volumes and readout times, enabling rapid observations of bright objects without saturation. If one of the SW masks is being used, data will be collected using the the appropriate SW detector. If one of the LW masks is being used, data will be collected on the LW detector. Choices for the **SUBARRAY** parameter are: **FULL**, **SUB640** (for the SW channel), and **SUB320** (for the LW channel).

Table 1. NIRCam coronagraphic imaging array and subarray properties

Subarray	Size in pixels $N_{\text{rows}} \times N_{\text{columns}}$	Short wavelength FOV (each side)	Long wavelength FOV (each side)	Frame time (s)	Detector Outputs
FULL	2048 × 2048	132" (with 4"-5" gaps)	129"	10.73676	4
SUB640	640 × 640	20.3"		4.17932	1
SUB320	320 × 320		20.7"	1.06572	1

Dither pattern

NIRCam coronagraphic imaging supports various [small-grid dithers](#). **DITHER PATTERN** values available for the round shaped coronagraphic masks (**MASK210R**, **MASK335R**, and **MASK430R**) are:

Table 2. Dither patterns for round shaped coronagraphic masks (**MASK210R**, **MASK335R**, and **MASK430R**)

Dither type	Number of dithers
<i>NONE</i>	0
<i>5-POINT-BOX</i>	5
<i>5-POINT-DIAMOND</i>	5
<i>9-POINT-CIRCLE</i>	9

DITHER PATTERN values available for the bar-shaped coronagraphic masks (*MASKSWB*, *MASKLWB*) are:

Table 3. Dither patterns for bar-shaped coronagraphic masks (*MASKSWB*, *MASKLWB*)

Dither Type	Number of dithers
<i>NONE</i>	0
<i>3-POINT-BAR</i>	3
<i>5-POINT-BAR</i>	5

Filters and exposures

The user specifies the *Filter* for the scientific observations. Available [filters](#) are a function of the chosen coronagraphic mask. The scientific exposure is configured by setting the [readout patterns and characteristic](#) parameters: *Readout Pattern*, *Groups/Int*, and *Integrations/Exp*. *Groups/Int* is limited to 10 for all readout patterns except *DEEP2* and *DEEP8*, which allow up to 20.

Total Dithers and *Total Integrations* are not user changeable and they reflect the values selected in the *Dither Pattern* and *Integrations/Exp* fields.

The resulting exposure time for each filter is displayed in *Total Exposure Time*.

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

PSF reference observations

In most cases, three or more coronagraphic observations should be defined to support [PSF subtraction](#):

- Science observation #1
- Science observation #2 with the telescope rotated by a specified offset
- PSF reference star

For a detailed description of the observational strategies, see the [Coronagraphic Sequences](#) page.

This is a PSF reference observation

Checking this box designates the observation as a PSF reference star used for [PSF subtraction](#) (A detailed discussion on the choice of a good PSF reference star can be found in the High Contrast Imaging pages.) The observation for a PSF reference star should mirror the observation for the user's science target. Note reference star observations have no proprietary period.

PSF reference observations

If this observation is of a science target, then use this field to associate it with an appropriate PSF reference observation (based on those that have been defined elsewhere in the observing proposal).

Additional justification

For a survey of many targets, they may serve as PSF references for one another. In that case, the user may check this box and explain with additional text in the science justification section of a submitted proposal. The user must still select the science targets as PSF reference observations in the list above.