JWST APT Coordinated Parallel Observations

Coordinated parallel observations can be specified in APT for certain combinations of templates, and are defined within the same APT proposal as the primary observations.

Introduction

> *See also: JWST Parallel Observations for an overview.*

Parallel observing is a technique that allows more than one instrument to be simultaneously operated to collect data, thus maximizing the scientific return from JWST. However, because of various operational constraints, including data rate and data downlink restrictions, there needs to be a science-driven justification for parallel observing. A separate article, JWST Parallel Observations, describes the high-level considerations.

Science parallels come in two basic varieties, *coordinated parallels* and *pure parallels*, and they are handled differently in APT. This article concentrates on coordinated parallels.

Coordinated parallels

Coordinated parallel observations are requested in the same proposal as their primary counterparts since they're intended to directly support the science goals of the program. Its implementation depends on the requested template combinations and characteristics of the individual instruments being used together, as well as which instrument is considered primary and which is parallel.

Combined templates for coordinated parallels

Table 1 shows the observing template combinations that have been approved for use in DD-ERS programs and Cycle 1 of JWST operations. Support for other modes are planned for future cycles, and will be announced when they become available.

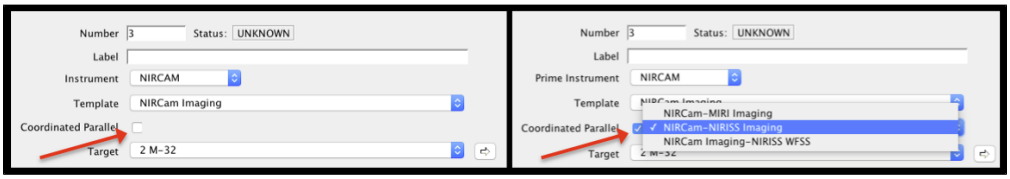
Table 1. Compatible observing template combinations

Ref no.	Template combination	Comments
1	MIRI Imaging – NIRCam Imaging	Either can be primary
2	NIRCam Imaging – NIRISS WFSS	Either can be primary
3	MIRI Imaging – NIRISS WFSS	Either can be primary
4	NIRSpec MOS – NIRCam Imaging	NIRSpec MOS must be primary
5	NIRCam Imaging – NIRISS Imaging	NIRCam must be primary

Note: for options 1, 2, and 3, either instrument can be the primary; for options 4 and 5, only one of the instruments can be the primary.

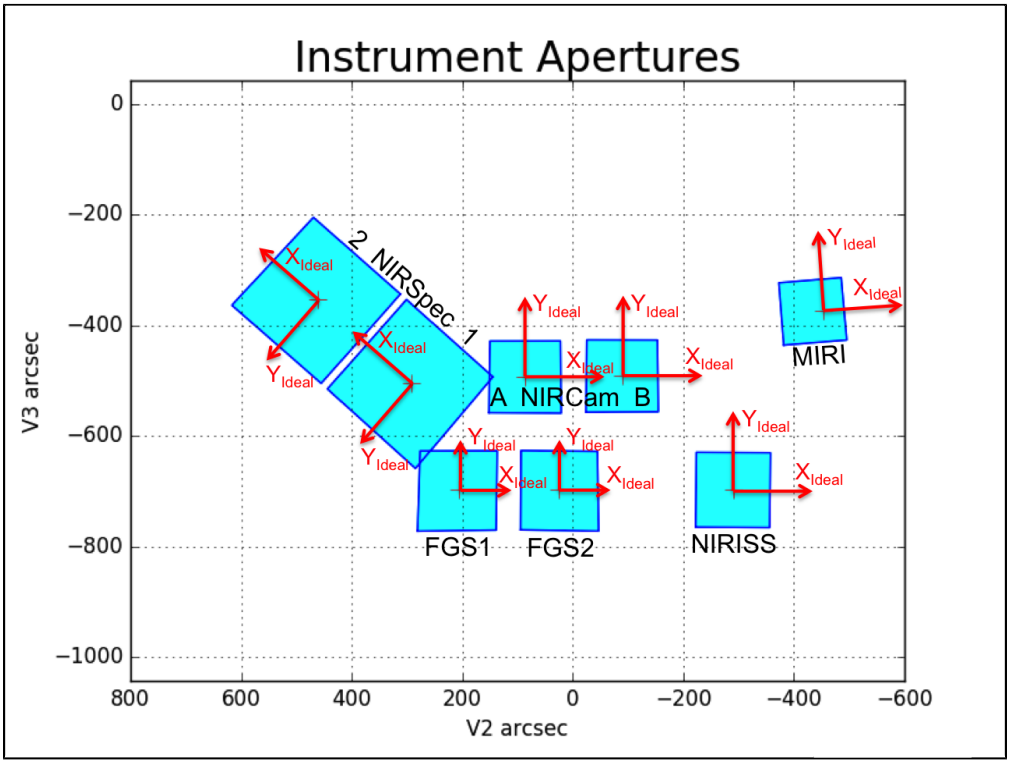
For any of the (primary) templates that permit coordinated parallels, the coordinated parallel option is invoked by checking the coordinated parallel button in the APT observation template GUI, then selecting the secondary (parallel) template option from the pull-down menu, as shown in Figure 1.

Figure 1. Selecting a coordinated parallel observation in the primary instrument observing template



The footprints of each instrument in the JWST focal plane are offset from each other, as shown in Figure 2. Hence, parallel observations do not view the same location, but rather are offset. Also, th exact regions to be observed will depend on the observatory position angle at the time the observation is scheduled. Note that the "Y" axes indicated in the figure are the reference vectors for measuring aperture position angles (APAs) for each instrument. See JWST Position Angles, Ranges, and Offsets.

Figure 2. JWST instrument detector locations in the JWST focal plane and ideal coordinate systems



JWST Focal Plane V2–V3 coordinate system with instrument fields of view shown as cyan rectangles. (For NIRCam, only the 2 long-wavelength detectors are shown.) For one SIAF aperture on each detector, the right-handed ideal coordinate system is shown in red.

General considerations

a. For coordinated parallel observations, every exposure of the primary instrument must have a parallel counterpart and vice versa. (This rule avoids mechanism moves with one instrument during an exposure with the other instrument. Such mechanism moves may in principle cause noticeable jitter.)

b. Every exposure with the parallel instrument must have an exposure *duration* (exposure time plus overheads) that is less than or equal to that of the corresponding exposure duration of the primary instrument. (This rule is enforced by APT, which will give an error if the rule is violated.)

c. Dither specifications are handled differently for NIRCam and MIRI. For NIRCam, a dither pattern is selected and applied to the (whole) observation. (For instance, multiple parallel exposures attached to the multiple primary visits/exposures of a NIRCam observation can only use a single dither pattern.) For MIRI, dithers are specific for a given filter choice, so in principle the dither patterns can change within a visit.

d. Using NIRISS WFSS in coordinated parallel mode causes significant complications, because of the need for direct images before and after the WFSS prism exposure(s). This forces "extra" undithered observations onto the other (primary) instrument to provide primary exposures that these direct images can be attached to (more details provided below).

Details of specific combinations (given as primary + parallel)

NIRCam Imaging + MIRI Imaging

In the coordinated parallel mode, there is no change in the way that NIRCam primary dithers are selected. At the sub-pixel dither selection, you can choose to just stay with the normal NIRCam options or choose any of a number of other "custom" dither patterns that provide a level of optimization of dither step sizes for the parallel instrument while retaining optimal pixel phase sampling for the primary instrument. A complication in this context is that the MIRI dither options are filter specific (to accommodate the varying PSF size of MIRI), but the selection made in APT applies to all exposures associated with the observation in question. Hence, some compromises are sometimes necessary for parallel observing. For example, you may need to choose a dither for a longer wavelength filter to accommodate some exposures, but that may be sub-optimal for any parallel exposures in the same observation for which MIRI actually observes at shorter wavelengths.

For MIRI in parallel, the exposures/dither parameter in MIRI Imaging can only be "1".

MIRI Imaging + NIRCam Imaging

With MIRI imaging as prime, the primary dither selection is where a standard MIRI dither or a custom dither for coordinated parallels would be selected. As mentioned above, MIRI dithers are filter-specific. Hence, different MIRI-optimized dither patterns can be selected for each individual NIRCam parallel exposure specification. (In other words, the NIRCam parallels may not all be done with similar dithers, unlike in the "NIRCam prime + MIRI parallel" case.)

NIRCam Imaging + NIRISS WFSS, MIRI Imaging + NIRISS WFSS

WFSS observations (whether in primary or parallel) require a direct image before and after the grism exposures (with a given grism and blocking filter). This complicates matters in coordinated parallels because it requires that "prime + parallel sets" of exposures come in groups of 3 exposures instead of one. Specifically, each set of exposure sequences specified in the NIRISS/WFSS template (consisting of a line of grism exposures plus a line of direct image exposures) requires 3 exposure specifications with the other instrument (NIRCam or MIRI). Of these three, the *second* exposure specification will be associated with the (dithered, typically relatively long) grism exposures of NIRISS WFSS, while the *first and third* exposure specifications will be associated with two (typically relatively short) direct images of NIRISS/WFSS. By default, the latter two exposures are single (undithered), and taken at the *first and last* dither position of the primary instrument's dither pattern. However, the user has the option of imposing the full dither pattern of the primary instrument also on the direct images of NIRISS/WFSS (this option is available in APT by setting the "Direct Image Exposures" pull-down selector to "DITHER_DIRECT_IMAGES").

The best way to accommodate this strategy is to add two (otherwise unnecessary) exposure lines under which you will specify the NIRCam or MIRI imaging exposures associated with the first and third exposures in the NIRISS WFSS sequence (i.e., the WFSS direct images). This breaks one of the key tenants of parallel observing, which is that the parallel observations should not impact the primary observations, but it is the only way to properly accommodate NIRISS WFSS in coordinated parallel mode. (See an example of a NIRCam imaging and NIRISS WFSS exposure combination.)

NIRSpec MOS + NIRCam Imaging

This combination will only be offered with NIRSpec MOS as the primary so it drives the pointing. The coordinated parallel version of the NIRSpec MOS template includes the option to add custom sub-pixel dithers to the nominal moves of the field of view by integer MSA shutters (i.e., the "nods" in the MSA Planning Tool). The sizes of these sub-pixel dithers are chosen to improve NIRCam image pixel sampling while staying small enough to avoid incurring significant slit losses with the NIRSpec MOS exposures.

NIRCam Imaging + NIRISS Imaging

NIRISS imaging is not offered as a primary mode, and so this pairing is always NIRCam primary. Similar to the NIRCam imaging + MIRI imaging combination, you can choose standard NIRCam dither options as well as a number of custom dither patterns that provide optimized PSF sampling for NIRISS and NIRCam simultaneously.