JWST Coronagraphic Observation Planning

Several suggested procedures and strategies are available for planning coronagraphic observations with JWST.

Introduction

> *Parent article: JWST High-Contrast Imaging*
> *Main articles: MIRI Coronagraphic Imaging APT Template, NIRCam Coronagraphic Imaging APT Template, NIRISS Aperture Masking Interferometry APT Template*
> *See also: NIRCam Coronagraphic Recommended Strategies, NIRISS AMI Recommended Strategies; and relevant examples in JWST Example Science Programs*

Coronagraphic and other high-contrast imaging (HCI) observations can be some of the most complex to schedule with JWST. Most HCI science requires the scheduling of a sequence of observations that collects data for the primary science target as well as a reference star to support point spread function (PSF) subtraction.

The JWST PSF is expected to be time variable, which has important consequences. For example, both the science target and PSF reference star will be reduced together; therefore, they should be observed as closely together in time as feasible in order to minimize changes in the PSF. This brings into play the issue of target visibilities, which is discussed later in this article. Unless on-orbit experience shows that this need for contemporaneous imaging can be relaxed, the JWST project requires observations of the HCI science target and PSF reference star to be planned and coordinated to execute together, in a back-to-back sequence of observations.

Ultimately, the limiting contrast is controlled by PSF variability.

Depending on the specific goals of your HCI science program, a number of planning options and issues may or may not apply to your particular program. For example, do your goals call for the default 10° roll dither on your science target? Is a larger position angle offset needed to recover a part of the scene that would otherwise be blocked by the selected coronagraphic mask (e.g., a face-on disk observed with a NIRCam bar occulter)? Is the highest quality PSF matching needed for your science? If so, perhaps you should consider the small grid dither (SGD) technique. In the case of NIRCam observations, do you need high accuracy astrometry? If so, perhaps you should obtain images for full field astrometry (FFA) in addition to the HCI science data (article pending).

Your most basic decision in planning HCI observations is your choice of wavelengths needed for the science. The choice of wavelength ranges will influence your choice of science instruments and the options for masks, filters, and detector operations. See the JWST High Contrast Imaging article for links to the details on individual instruments.

Estimating your exposure times is a science-critical aspect of observation planning. You must estimate exposure times for both science observations and target acquisition, which is crucially important for the success of coronagraphic observations. You can estimate exposure times using the JWST Exposure Time Calculator. Some HCI-specific suggestions on using the ETC are available in JWST Coronagraphy in ETC.

Below, this article treats planning topics in more detail, providing links to other articles for additional information.

Planning considerations

Main articles: JWST Position Angles, Ranges, and Offsets, JWST Coronagraphic Visibility Tool Help

Outlined below is a suggested flow of planning considerations to help you through the process. We recommend checking target visibilities first (since running ETC calculations for a target that is not observable at the necessary position angle on the sky is a wasted effort). Also, some users may want to consider the strategy issues up front in their planning.

1. Check target visibilities. Target visibilities can enter planning in several ways. Even if there are no restrictions on the placement and orientation of the coronagraphic field of view, you must still find a suitable reference star to support PSF subtraction. Check and verify that both the science and PSF reference targets can be observed at the same time. In cases of known or expected structures around the science target—the companion sources of interest, such as disks or exoplanets—then it is desirable to place that structure optimally with respect to the masks in a given JWST coronagraph. For JWST, position angle flexibility is a strong function of the target's ecliptic latitude. Therefore, before investing a lot of effort in estimating exposure times, check to see if your desired observations are possible. The Coronagraphic Visibility Tool (CVT) is an important resource for such pre-planning and observational strategizing. The CVT computes both visibility windows and available position angles as functions of time for MIRI and NIRCam coronagraphs. The CVT also provides visualizations of the focal plane projected onto the sky, which is useful for evaluating the placement and orientation of known science sources on the coronagraphic masks.

2. Make some general strategic decisions: will you require astrometric images (NIRCam only)? Will you use the (default) roll dither technique for your science target (or not)? Will you want to use the SGD technique for your observation(s)?
   Define the content and structure of your coronagraphic sequences, such as:
   a. Which instruments and coronagraphs/filters/occulters are needed for each target?
   b. Verify that the standard sequence applies, and that neither a roll dither nor a reference star is required.
   c. Decide on how to handle sequences of multiple filters or, in the case of MIRI, multiple coronagraphic masks.
   d. Decide if SGDs and/or full field astrometry (FFA) are needed.
   Preparing for such decisions ahead of time will streamline your planning activities in ETC and APT.

3. Once you have established target visibility and adopted a strategy, use the JWST ETC to calculate exposure parameters for all types of observations, such as science, PSF reference, target acquisition (TA), and FFA.

4. You will need to have in mind the systematic limit of coronagraphic performance, as expressed by the limiting contrast, which is a function of the apparent separation between host and companion. Evaluating limiting contrast may help you decide on such matters as whether the highest quality PSF subtraction is needed, which might drive you to consider whether the extra time needed to employ the small grid dither technique is "worth it" for your science.

5. When you have addressed these considerations, you are ready to enter your observations into APT and craft your actual observing program. You may wish to review the concept of coronagraphic sequences and their purpose. Collecting all relevant observations for a given coronagraphic sequence in its own APT observation folder will help to keep your proposal organized. For a general overview, see JWST High-Contrast Imaging in APT**.** For detailed, step-by-step help, see these APT template guide articles: NIRCam Coronagraphic Imaging, MIRI Coronagraphic Imaging, and NIRISS Aperture Masking Interferometry.