Coordinated Parallel Exercise #1: NIRCam Imaging with MIRI Imaging in Parallel

This example is modeled after a "Deep Field Imaging" proposal, but has been simplified for use here. Details of the original proposal are provided under the *Reference materials* section below. The text shown in **BOLD** highlight actions within the more general text.

Start with the APT file *Parallel_Exercise1_start_MC19.aptx* provided, which has a single target and two simple NIRCam observations with different filters as a starting point. (Usually multiple filters would be placed in a single observation, but in this case, each exposure is so long for the Deep Field case that it makes sense to put them in separate observations.) The target is the GOODS field South, and we want to craft a mosaic of a region and add MIRI imaging of an adjacent field in parallel, also using two filters (F770W and F1500W). Here are some steps to guide your work.

1) **Load the APT file into APT** and look at the target and observation sections to see what is there.

2) Let's play with the NIRCam F115W/F277W observation first. Much of what we do can be duplicated in the 2nd observation with the other filters.   **Create a default 2x2 NIRCam mosaic, and view the mosaic in Aladin. Load the DSS image** as a background image. Initially no dithers have been specified, so gaps appear in the coverage. This will be fixed later.

3) We would like to align this mosaic approximately with the existing GOODS FoV, so use a special requirement to **set the allowed angle range to Aperture Position Angle 280 – 300 degree**s. Note the change in the Aladin display.

4) Before deciding on a dither pattern, we want to **add MIRI imaging as a coordinated parallel**, and then choose a dither pattern that will work for both instruments. So add placeholder MIRI parallel exposures as a starting point.

> a) **Check the Coordinated Parallel box** in the template **and choose NIRCam-MIRI Imaging.** Note the addition of a tab for MIRI.
> b) **For MIRI choose the FULL subarray, MIRI F770W filter and FAST readout pattern**.
> c) **Add 100 groups and 1 integration just as a placeholder**. We will investigate expanding this to fill the time later in the exercise.

5) **Go back to the NIRCam observation and choose an appropriate dither pattern that works for both.**

      a) A real user would want to understand the choices of primary dither pattern in terms of covering detector gaps and uniformity of field coverage. Initially, the file had specified NONE for primary dither just to keep the display simple. Now let's **choose the FULL primary dither pattern with 3TIGHT primary option.**

      b) Now look at the Subpixel dither options. These sub-pixel dither patterns have been defined to sub-sample both the NIRCam and MIRI pixels. Because MIRI covers such a broad wavelength range (and the size of the MIRI PSF varies with wavelength), the defined dither patterns depend on the filter(s) to be used, which are **F770W and F1500W**. Let's say we want 9 total dither steps. **Choose the subpixel dither that matches the MIRI filters and provides the total number of dithers we want.**

      c) Note that the number of dithers (and total exposure time) have increased.

      d) Also note in Aladin how the dither pattern selection has filled in the coverage.

6) **Adjust the NIRCam mosaic overlap** so the MIRI mosaic does not have gaps and has a modest amount of overlap. What values of the NIRCam overlap parameters do you find?

7) With the observation selected in the tree editor, **look at the observation in APT Timeline**. Note length of MIRI exposures relative to the NIRCam primaries. Can they be lengthened to better use the available time?

8) **Adjust the MIRI parallel exposure specifications** until the parallel exposures are comparable to the primary exposures. In general, you should try to adjust the number of groups/int first, and then increase the number of integrations if needed. In this case, the NIRCam exposures are so long, just start with 4 integrations and increase the groups/int.

      a) How many groups can be used before APT says the parallel is too long?

      b) **Look at the observation again in the APT timeline display** to see how the parallel is now matched to the primary.

9) Now **select the observation and run the Visit Planner** to verify schedulability.

10) **Change the label on the observation** from "F115W SW + F277W LW" to something more descriptive of your combined parallel observation. (This sort of "bookkeeping" can help you when you look back at the proposal at a later time!)

11) Now **modify NIRCam observation 2 to be consistent with the first**. (Hint: think about what might be the fastest way to do this.) Select MIRI filter F1500W for the parallel in this case. Question: should we use the same dither strategy for both Observations? Next, **check the schedulability of this second observation**. If you duplicated and modified the first observation to create the second, be sure to **change the label on the second observation** to avoid confusion.

Note: Observation folders can also be named as appropriate to manage and organize your proposal. **Rename the NIRCam Imaging folder to something more appropriate**. Observations can also be dragged and dropped in the tree editor of APT if desired. You could try this by swapping the order of your two observations from above.

If you wanted to perform the same (or similar) set of observations on another target, you could duplicate the entire observation folder, then edit the other target into the copy and make whatever other adjustments were needed to exposure specifications as appropriate.

Extra Credit: When adding parallel exposures, you should look at the S/N you will get with them and decide whether they accomplish your science goals. This was skipped above in the interest of time. This check should be ultimately done with ETC, but you might first want a quick sanity check to make sure the parallel exposures make sense.

For our example, to get a quick look at the sensitivity of the MIRI parallel exposures, you can use the **JWST Interactive Sensitivity Tool (JIST**), which has just been released for use by Master Class participants. (It will be made fully available for Cycle 1 proposers as well.) JIST is an interactive GUI that runs in your browser and allows you to choose an instrument and mode, and adjust source brightness and exposure time to see what S/N can be achieved. The grid of models used by JIST assumes a point source with a flat spectrum, so it is only an approximation, but in many cases good enough to provide useful insight. The link for JIST is here: jist.stsci.edu

And the JDox support page for it is here:
https://jwst-docs.stsci.edu/other-tools/jwst-interactive-sensitivity-tool

As an exercise, find the exposure time needed with MIRI imaging and FF770W filter to reach a S/N of 10 for an AB=24 point source. Is this S/N achieved for the MIRI exposures specified above?

This simplified exercise is based on an Example Science Program you can read about in JDox:

Example Science Program 22 overview
https://jwst-docs.stsci.edu/near-infrared-camera/nircam-example-programs/nircam-deep-field-imaging-with-miri-imaging-parallels

The ETC Step-by-step guide:
https://jwst-docs.stsci.edu/near-infrared-camera/nircam-example-programs/nircam-deep-field-imaging-with-miri-imaging-parallels/step-by-step-etc-guide-for-nircam-deep-field-imaging-with-miri-imaging-parallels

The APT Step-by-step guide:
https://jwst-docs.stsci.edu/near-infrared-camera/nircam-example-programs/nircam-deep-field-imaging-with-miri-imaging-parallels/step-by-step-apt-guide-for-nircam-deep-field-imaging-with-miri-imaging-parallels

Coordinated Parallel Exercise #2: NIRISS WFSS with NIRCam Imaging in Parallel

This example is modeled after a "Deep Field" proposal. Details of the original proposal are provided under the *Reference materials* section below. The text shown in **BOLD** highlight actions within the more general text.

Start with the APT file provided (*Parallel_Exercise2_NIRISS_only_MC19.aptx*), which has a single target and an NIRISS WFSS observation with different filters, and two orthogonally mounted grisms, as a starting point. The target is the center of an HST Frontier Field galaxy cluster, and we want to add NIRCam imaging in parallel of an adjacent field. As background information, the main science goals are:

- Measure star formation rates (SFRs) and abundances of dwarf galaxies from 1 < z < 5
- Spatially resolve emission lines of lensed galaxies at z > 1
- Detect "extreme" emission-line galaxies (ELGs) at 1 < z < 8 and determine their evolution through number densities
- Discover and characterize ELGs in re-ionization era (z > 7) via spectral diagnostics (continuum breaks, dropouts, Ly alpha)
- Parallel science: in cluster outskirts, detect candidate galaxies with strong emission lines based on medium-band photometry. We require NIRCam images through 12 filters (6 in each channel), at similar depth:
  - SW channel: F090W, F115W, F140M, F150W, F182M, F210M
  - LW channel: F277W, F250M, F300M, F335M, F360M, F410M

Here are some steps to guide your work.

1) **Load the APT file into APT** and look at the NIRISS WFSS observation to see what is there.
   a. **Look at the three sections of the Observation** ("Science Observation", "Direct Image Exposure Parameters", and "All Exposures Display"), and see how the "All Exposures Display" relates to the two other sections.
   b. Note that each WFSS "Science Observation" sequence is associated with *two direct image exposures*: One *before* and one *after* the grism exposures (each at a different dither location to improve pixel sampling). These direct images are needed (i) to identify the targets and (ii) to provide the zeropoints for the wavelength calibration.
   c. All three exposures of a WFSS sequence need to get associated with coordinated parallel exposures.
   d. **Also click on the "Image Dithers" and "Pattern Size" pulldowns** to see the options, and take note of those selected.

Load the DSS image as a background image in Aladin.

2) Before deciding on a dither pattern, we want to **add NIRCam imaging as a coordinated parallel**, and then choose a dither pattern that will work for both instruments.
   a. **Choose "Coordinated Parallel" and "NIRISS WFSS – NIRCam Imaging"**
   b. **In the NIRCam Imaging tab that just appeared, select "Module = ALL" and "Subarray = FULL"** (the parallel science benefits from maximizing the field of view).

c. **Add 3 placeholder NIRCam parallel exposures as a starting point** (i.e., the 3 that are in parallel to NIRISS WFSS exposure sequence #1).
Choose the NIRCam filters F210M/F250M and the SHALLOW2 readout pattern.
Select 3 groups and 1 integration just as a placeholder. We will investigate expanding this to fill the time later in the exercise.

3) **Go back to the NIRISS observation and choose an appropriate dither pattern that works for both**.

   a) Note the new dither options ending in "NIRCam". These are the dither patterns that are customized to work well with both NIRISS and NIRCam (relevant if improving pixel sampling with the NIRCam parallels is important).

   b) The NIRISS WFSS exposure times (by themselves) were selected for 8 dithers (minimum). How would you go about selecting the appropriate dither pattern after having added the NIRCam Imaging exposures? **Select that dither pattern**.
Also note in Aladin that the NIRCam footprints have been added. (Note that if one would want the NIRCam parallels to cover its detector gaps, one would have to use mosaicking.)

6) **With the observation selected in the form editor, look at the observation in APT Timeline. Note length of the 3 NIRCam exposures relative to their associated NIRISS primaries.** Can the NIRCam exposures be lengthened to better use the available time?

7) **Adjust the NIRCam parallel exposure specifications until the parallel exposures are comparable to the primary exposures**. Do this by first changing the Readout Pattern, then increasing the number of groups/int.

   a) Taking into account that having a minimum of 3 groups per integration is recommended, and that data volume can become an issue with parallels if NIRCam is involved, what readout pattern will likely be optimal for the NIRCam exposures? **Select that readout pattern**.

   b) How many groups can be used before APT gives an error? **Select that number of groups**.

   c) **Look at the observation again in the APT timeline display to see how the parallel is now matched to the primary.**

Note: as already noted during the NIRCam Imaging + MIRI Imaging exercise, in reality one should look at the S/N you will get with the parallel exposures and whether they accomplish your science goals for the NIRCam observation. (In this case this part was already performed in advance.)

8) **Fill out the remaining parallel NIRCam exposures**. How many in total?
Now for the NIRCam filter selection of the exposures just added, we would like to minimize the mechanism move-related overheads, which can be substantial for NIRCam (and overheads are included in the total requested time). How would we go about doing that?

9) **Now select the observation and run the Visit Planner to verify schedulability**.

10) **Determine "good" ranges of position (roll) angle to avoid bright stars falling into the NIRCam FOV, and enter those ranges into the APT GUI** (how?). **Re-run the Visit Planner.**

11) **Go back to the first Science Observation (or "Sequence") and click on the Grism item**. Note that the proposal selected one grism at a time rather than "BOTH", even though both grisms are actually being used. Any idea why that selection might have been made? Hints:
   a) **Look at what happens to "All Exposures Display" when changing "Grism" to "BOTH" on the first WFSS sequence**.
   b) Remember that we need NIRCam images through 12 filters (6 in each channel).

Extra Credit (if there is time): What if you wanted to observe this field again when the camera FOVs were reversed (i.e., to get NIRISS coverage of [part of] the NIRCam footprint and vice versa)? How would you go about checking out that possibility?

This simplified exercise is based on an Example Science Program you can read about in JDox:

Example Science Program 33 overview
https://jwst-docs.stsci.edu/near-infrared-imager-and-slitless-spectrograph/niriss-example-programs/niriss-wfss-with-nircam-parallel-imaging-of-galaxies-in-lensing-clusters

The ETC Step-by-step guide:
https://jwst-docs.stsci.edu/near-infrared-imager-and-slitless-spectrograph/niriss-example-programs/niriss-wfss-with-nircam-parallel-imaging-of-galaxies-in-lensing-clusters/step-by-step-etc-guide-for-niriss-wfss-and-parallel-nircam-imaging-of-galaxies-in-lensing-clusters

The APT Step-by-step guide:
https://jwst-docs.stsci.edu/near-infrared-imager-and-slitless-spectrograph/niriss-example-programs/niriss-wfss-with-nircam-parallel-imaging-of-galaxies-in-lensing-clusters/step-by-step-apt-guide-for-niriss-wfss-and-nircam-parallel-imaging-of-galaxies-in-lensing-clusters

Reference materials:

JDox articles on parallels with JWST:
JWST Parallel Observations article
Coordinated Parallels Roadmap article
APT Coordinated Parallel Observations article

The APT Video tutorial on APT Timeline and on Mosaicking may also be helpful as well:
APT Graphical Timeline
Specifying Mosaics in APT