JWST Master Class 2020

Coordinated Parallels hands-on

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Coordinated Parallels with JWST

Activity I: Adding spokes to the North Ecliptic Pole Time Domain Survey

Science Motivation

The North Ecliptic Pole (NEP) Time Domain Survey (TDS, PI Windhorst, proposal 1176) is a GTO Programme that uses JWST as a Time-Domain Observatory. It will observe a small field close to the NEP taking advantage of its location within JWST's northern Continuous Viewing Zone, thus being observable at any time of the year. Furthermore, the TDS has low galactic attenuation and a very small number of bright stars (preventing detector saturation) and the survey is designed to track very faint variable and transient sources over the lifetime of JWST. The TDS observations use coordinated parallels of NIRCam photometry and NIRISS Wide Field Slitless Spectroscopy to identify and follow-up sources such as supernovae, active galactic nuclei, brown dwarfs and Kuiper belt objects in the field.

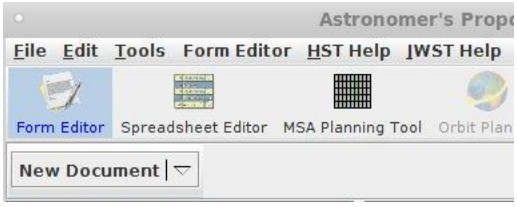
Description

The aim of this exercise is to obtain additional data for an already existing programme; it will concentrate on the preparation of the APT file allowing the user to become familiar with filling APT for coordinated parallels.

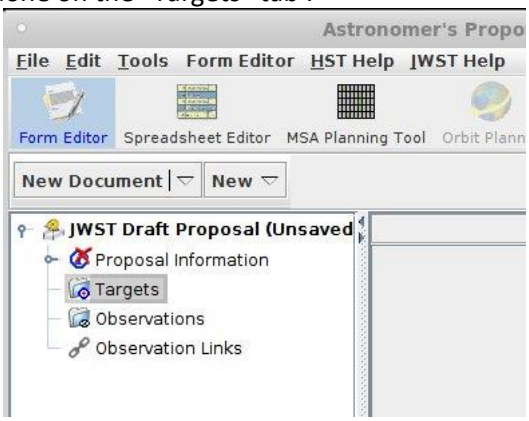
The TDS uses several NIRCam filters to image the field and to determine photometric redshifts; NIRISS Wide-Field Slitless Spectroscopy is taken in parallel with the dual purpose of characterising and monitoring variable sources and calibrating the photometric redshifts. The survey design has the footprints of both instruments overlapping after about 180 days. The NIRCam observations are planned to cover the gaps between both modules and the gaps between the detectors in the short-wavelength channel and insure the long-wavelength images are contiguous. Images are taken through 6 short- and 6 long-wavelength filters to probe the observed spectral energy distribution of sources from about 0.9 to 4.5 microns down to limiting (AB) magnitudes of about 29. The NIRISS observations use both 150 l/mm gratings which have spectra perpendicular to each other so that overlapping spectra can be separated. NIRISS also requires direct imaging observations of the field required to map the location of sources in the spectroscopic data and to provide the wavelength calibration. The selection of filters and exposure times uses values proposed by the Windhorst GTO Team which were optimised for the measurement of photometric redshifts, i.e., using longer exposures for filters that can help identify objects of high redshift.

Filling in the APT

1. Create a new JWST proposal under the "File" tab at the top left corner:



2. Create the target. This is done on the "Targets" tab :



where one inputs a "New Fixed Target

3. After pressing the "New Fixed Target" option enter these coordinates for RA and DEC:

- 17:22:47.896 +65:49:21.54
- Set uncertainties to 0.5 arcsec, proper motions in RA and DEC to 0, epoch to 2000.0, parallax to 0
- Name in the Proposal: NEPSPOKES67 (note that the name is restricted to letters and numbers).
- Name for the Archive: NEP_Spokes_06_07

4. Proceed to fill the Observations spreadsheet by highlighting the observations button and pressing "New Observation Folder". Once the folder is created, go to the "Observation 1" sub-folder and highlight it. Define the following:

- Instrument: NIRCAM
- TEMPLATE: NIRCam Imaging
- Coordinated Parallel: check the box and select NIRCam Imaging -NIRISS WFSS
- Target: NEPSPOKES67
- Module: All
- Subarray : FULL
- Dither Parameters: INTRAMODULE
- Primary dithers: 3
- Subpixel Dither Types: NIRCam Only
- NIRCAM Positions: 1
- Direct Image Exposures: DITHER_DIRECT_IMAGES

5. Add filters:

Short Filter	Long Filter	Readout Pattern	Groups per Int.	Int. per expos.
F150W	F356W	MEDIUM8	5	1
F090W	F444W	DEEP8	6	1
F150W	F356W	MEDIUM8	5	1
F200W	F277W	MEDIUM8	5	1
F115W	F410M	DEEP8	6	1

F200W	F277W	MEDIUM8	5	1

6. Set Mosaic Properties (play around with these values and inspect footprint on Aladin)
   - Rows: 1
   - Columns: 2
   - Row Overlap: 10.0%
   - Column Overlap: 57%
   - Row Shift: 0.0
   - Column Shift: 0.0

View footprint In Aladin.

7. Special Requirements:
   - No parallel (i.e., this disables pure parallels being taken)
   - Aperture PA Offset: set to the desired PA +/- 15 degrees
   - Offset: 190 arc sec -98.0 arcsec

8. Add NIRISS Wide Field Slitless Spectroscopy

Grism	Filter	Readout Pattern	Groups per int.	Int. per expos.
GR150C	F200W	NIS	13	2
GR150R	F200W	NIS	13	2

Direct Imaging Parameters		
Readout Pattern	Groups per integration	Integrations per exposure
NIS	11	1
NIS	11	1

9. This configures the first spoke. Now configure Spoke 7 such that both instruments overlap. The trick to do this is by duplicating the observation and then setting the PA offset under Special Requirements.

10. Run the visit planner to determine when each configuration can be observed and calculate the total duration.

11. Save your work, but do not close the file just yet.

12. Notice that in our discussion we did not mention the position angle of the observations, only the offsets. To select a position angle that complements those used in the original proposal, download the APT file for proposal 1176 from STScI and view the footprints of both on Aladin.

Activity II: NIRCam Imaging with MIRI Imaging in Parallel

This exercise was prepared for the STScI JWST Master Class in November 2019, and the following text is a copy of the STScI original.

This example is a simplified "Deep Field Imaging" 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 *coordinates_parallels_exercise_2_nrc_miri.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 long enough 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 range to Aperture Position Angle 280 – 300 degrees**. 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. 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 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, edit the target and then make whatever other adjustments were needed to exposure specifications.

Extra Credit: When adding parallel exposures, you should look at the S/N you will obtain and decide whether they accomplish your science goals. This was skipped above, but should ultimately be done with ETC. For now, you could make a quick sanity check to ensure the parallel exposures are plausible.

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;** jist.stsci.edu). 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, will be good enough to provide useful insight.

JIST JDox support page:
https://jwst-docs.stsci.edu/other-tools/jwst-interactive-sensitivity-tool

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

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