JWST Master Class 2020

MOS hands-on

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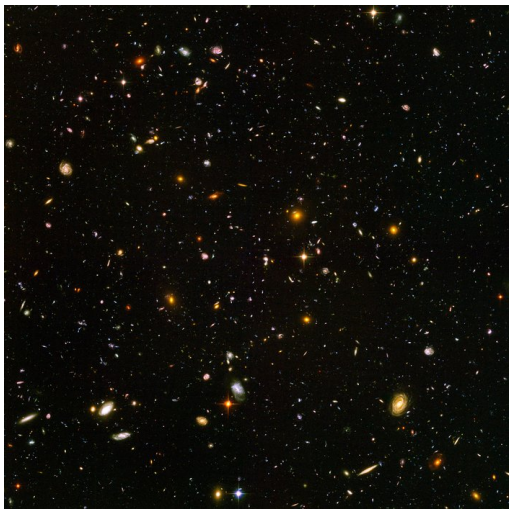
NIRSpec MOS Observations of HUDF

1. Background

The Hubble Ultra-Deep Field (HUDF) is a snapshot of almost 10,000 galaxies of various ages, sizes, shapes, and colours. It is a representative deep galaxy field, and one of the closest examples we currently have to JWST imaging depths.



In this hands-on session, we build an observational program in APT/MPT to obtain deep exposures of a 100+ galaxies in the HUDF simultaneously.

2. Plan your observation (10 mins)

Task: Prepare an observation layout to implement in the APT/MPT.

Your Inputs: Basic building block of 3 exposures corresponding to a 3-shutter nodding scheme; 72 exposures in CLEAR/PRISM; 24 exposures in each of F100LP/G140M, F170LP/G235M and F290LP/G395M

The "not-so-compatible" desires when designing the observations:

- Obtain each group of 3 nodded exposures at a different location on the detectors (i.e. in different slitlets) in order to minimize systematics (e.g. from the flat-field correction) and to work around detector defects (bad pixels).
- Your goal is to obtain as many of your objects as possible in all exposures (i.e. your objects should see the complete integration time) and you want to get as many as possible (best possible multiplexing).

But… when dithering, you reduce your effective field of view which is the intersection of the footprint of NIRSpec fields of view at each dither position.
While… dithering effectively reduces the number of objects you can observe in all exposures, but is recommended to improve spectral and spatial sampling.

Your solution will depend on your science case. Here, depth is very important so we will choose to put more emphasis on obtaining as many common objects as possible between the exposures. You should therefore limit the number of dithers, and only use small dithers corresponding to offsets of a few shutters.

Planning the layout of the observation: Assume that we will limit ourselves to 3 dither positions and at each, we will do a "3-shutter nod". Complete the table below to allocate the correct number of exposures at each nod/dither position, for each spectral configuration.

Dither	Nod	CLEAR/PRISM	F100LP/G140M	F170LP/G235M	F290LP/G395M
1	1				
	2				
	3				
2	1				
	2				
	3				
3	1				
	2				
	3				
TOTAL Exps		72	24	24	24

3. Begin in APT (10 mins)

Task: Launch APT and load the catalogue

- Launch APT and create a new JWST proposal
- Go directly to the **Targets** folder. (Ensure you are in the **Form Editor**)
- Open the provided catalogue ASCII (whitespace separated) file:
    - **HUDF_ordered_cat.txt** (from Rafelski 2015)

- Help APT identify all the columns you plan to use as filters, e.g. If you plan to filter on redshift, ensure to declare which column contains redshifts
- Ensure the **flux units** are denoted as **magnitudes**
- You will need to click on the catalogue to fill in some missing fields:
    - Astrometric accuracy: must be <50mas, put 15 mas for this exercise because these source positions were derived from HST WFC3 and ACS data
    - Pre-image: already obtained, as the catalogue is derived from HST imaging

Once complete, there should be no more red error flags.

4. Set-up the observation in the MPT Planner (10 mins)

Task: Go to the MSA Planning Tool "Planner" tab and fill in all the necessary details ready for optimization of a plan.

- For this simple exercise, pick the catalog as the **Primary Candidate list**.
- Select an **Aperture Position Angle (APA)**: 135 degrees, which is suitable for the orientation of the HUDF footprint on the sky.
    - In reality, you would use the visibility tools to determine the suitable range of APA
    - IMPORTANT: You need to select an APA to run MPT, but this angle is NOT fixed for your proposal unless you explicitly specify it as a Special Requirement. If you do not have a scientific or observational driver to fix it, then don't. You will be allocated an APA when the observation is scheduled.
- We want to maximize the multiplexing, so do not put strong constraints on the centering of sources in the shutters (**Entire Open Shutter Area**)
    - As each object will have a different centering in its open shutter, we must set the shutter **acceptance zone** for the optimization
- **Dither** setup: select parameters corresponding to your table in Part 2
    - We will use the **fixed dither** scheme, with 3 dither points, and keeping dither sizes small (5 shutters in both directions)
    - Due to distortions, different sources at the MSA plane will move by slightly different distances between dither points. Small dithers of a few shutters will limit the number of targets missed due to this
- **Gratings/Filters**: How to best ensure all of the same sources are in all exposures for each of the gratings? HINT – the tick boxes
- Define the **search grid**
    - Limit the search grid to 40"x40" and a step of 3"
    - The search grid size and step define the number of positions explored during optimization. The grid can quickly become VERY large and may take a while to compute! Try small numbers at first and increase progressively as you figure out how long this is going to take on your machine
- Set the number of configurations to the minimum as you have fully constrained the observation sequence above (you do not want to repeat it several times). How is the minimum computed?

5. Generate the plan (10 mins)

Task: Generate the Plan and examine the results

- Click on "**Generate the Plan**"… and wait a few minutes
- In the **Plans** tab of MPT, how many of the same sources did you get in all the exposures?
- How many are contaminants? You can filter the results to see how many. Since the entire catalog was used, the number should be realistic.
- ADDITIONAL TASK (for after the session):
    - Try other planning parameters:
        - Use target weights. Do you get better results? How can you tell?

6. Create the observation (5 mins)

Task: Select the plan you like, and create an observation

- Select one of the plans
- Click on "**Create Observation**"
- In the **Form Editor**, go to the newly created observation
- Fill in any missing information.
- Exposure duration parameters are selected here. Recall how you planned to divide up the exposure time. Try to get the number of exposures you planned
- Examine the number of visits, the overheads…
- For the medium resolution exposures, where you want to distribute 8x3 exposures over 3 dither positions, it cannot be achieved in a single observation
    - In this session, go for **27 exposures** distributed in **9x3** for simplicity
    - ADDITIONAL TASK (for after the session):
        - Create multiple observations and attempt to gain the correct number of exposures
- When assigning a large number of integrations (CLEAR/PRISM) you will be given a red error flag. HOWEVER, you can have several lines in the exposure setup table with the same spectral configuration – use this to clear the error, but beware, this will also increase the overheads
- Note that **MSATA** (target acquisition) parameters should be defined
    - ADDITIONAL TASK (for after the session):
        - This requires extra columns in your input catalogue, and a list of suitable reference stars within the same field of view
- Do you want **Confirmation images**?
    - ADDITIONAL TASK (for after the session):
        - Select sensible parameters for the brightness of the sources. These images are limited to 3 groups. Be aware that there are extra overheads for changing readout patterns in an observation
- **Review the program**: Do you have any remaining errors or warnings?