Tutorial : MIRI Low-Resolution Spectrometer (LRS)

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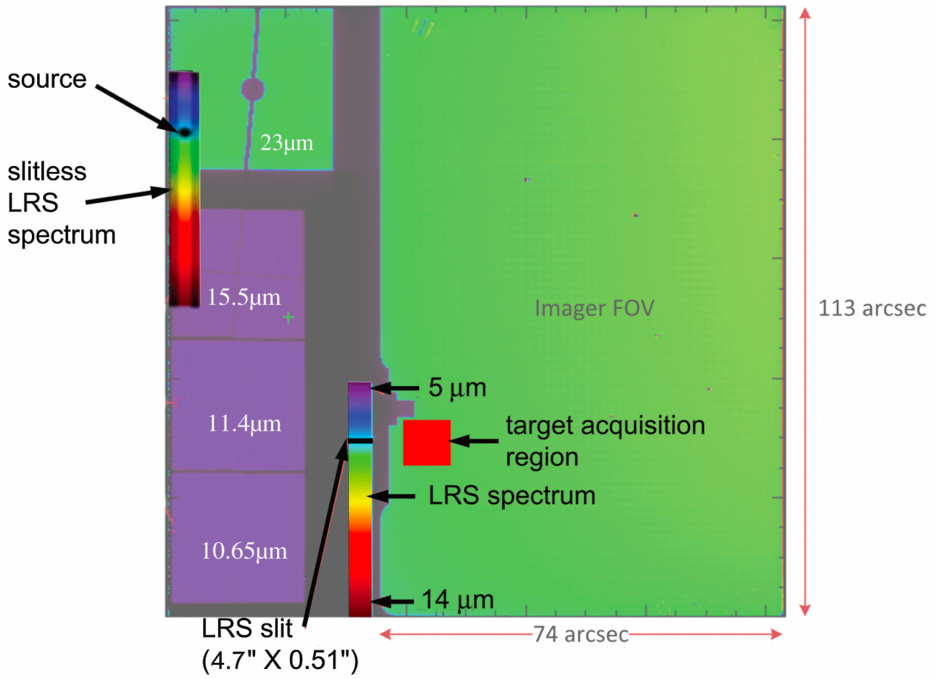
1. Brief description of the l'instrument

MIRI has 2 main physical parts :

- the Mid-Resolution Spectrometer (MRS);
- Everything else (chronographs, camera, low-resolution both with and without a slit, TA).

We will focus on the "everything else" part. The detector is schematized below.



The rainbow rectangles are the two sub part of the detector used for the LRS. This mode
has a resolving power between going from 50 at 5 microns to 250 at 14 microns. It is very useful for faint targets because it requires less flue than the MRS. Molecules like water, ammonia, methane, SO2, or silicate clouds have clear features in the wavelength range. The Slitless mode is usable for Time-Series Observation (TSO) and has a dedicated subarray which allows for bright targets (perfect for transits). The slit has, however, 10 times less background thanks to the slit and the obstructed pixels (gray in the scheme above) so more suited for fainter targets.

Aim : walk you through the steps to create a proposal for MIRI LRS using both the ETC and the APT.

2. Proposal for WD 0806 661 b

1. Context : Y0 Dwarfs

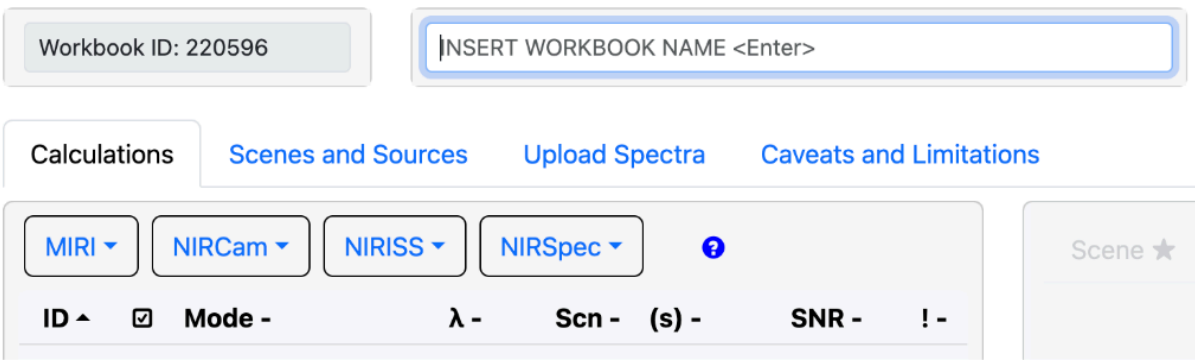
The limit between brown dwarfs and giant exoplanet isn't well characterize. The Y class of brown dwarfs contains the objects with an effective temperature of 500 K and less. They show prominent water, methane, and ammonia absorption features. With JWST, we are now capable of detecting and characterizing such Y dwarfs with effective temperature below 300 K opening a new window on atmospheric dynamics and chemistry.

2. Target information

The discovery paper is here and the latest one here. The data on the target is quite sparse, position, distance, a rough estimate of the system's age and 3 magnitudes.

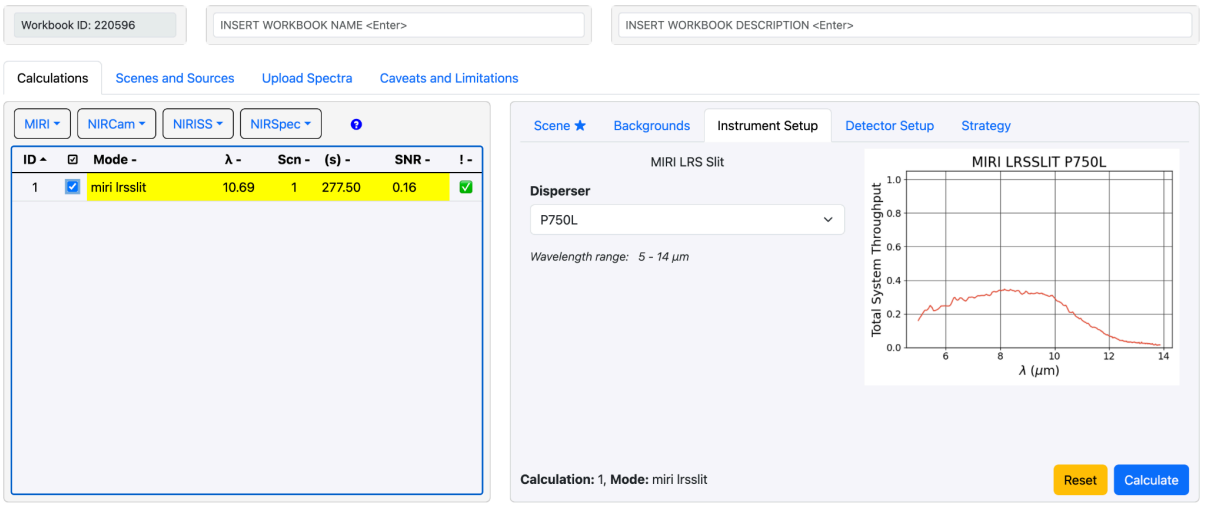
3. ETC Calculation

- Go to https://jwst.etc.stsci.edu/ , if you have created a MyST account login otherwise go as anonymous.
- "Create New WorkBook" then double-click on it.
- Rename it as you prefer.



- Then in "Calculation" click on "MIRI" and "LRS Slit"

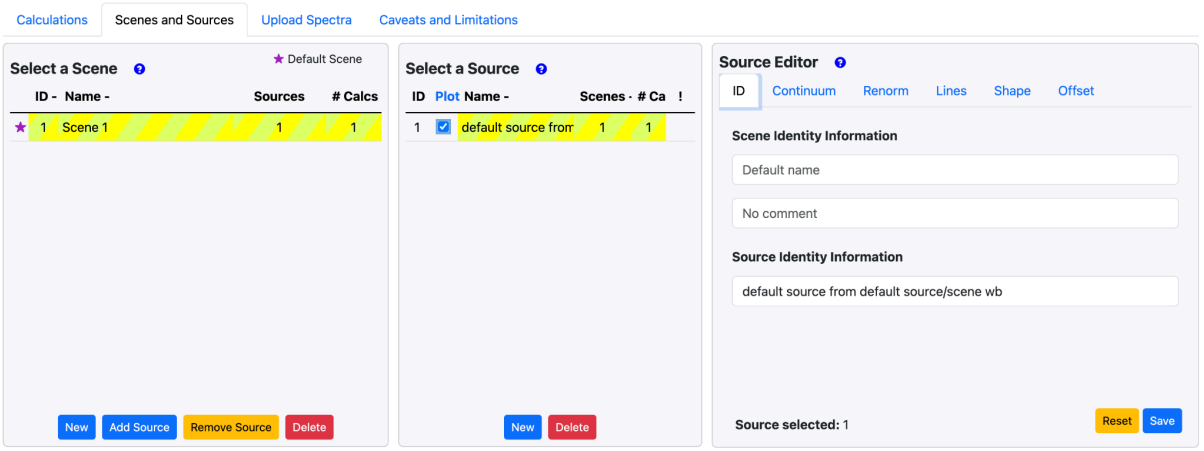
After clicking on the line that just appeared, you should now have something like this :



You can repeat that last step by changing the instrument and / or the mode. It will open a new line, and you can do the computations with the selected instrument model.

Now switch from the “Computation” to the “Scene and Sources” tab :

- Click on “scene 1”, “default source …” and the “ID” panel, and you should have this :



We will just add a single source, but you could image having several defined and used them either in a separate scene or all in the same scene if you need. In the left panel, you manage your scenes, i.e., an assembly of source. The panel in the center allows you to manage your list of sources. You change the properties of s source by clicking on it and going through the right-hand side panel.

In “Continuum” section “Spectral Energy Distribution” select “Low-temperature Phoenix model” then below “350 K”. In “Renorm”, normalize in band pass

select “Other” and then “Spitzer” and below “IRAC 4.5” at set the value at 16,96 vegamag.

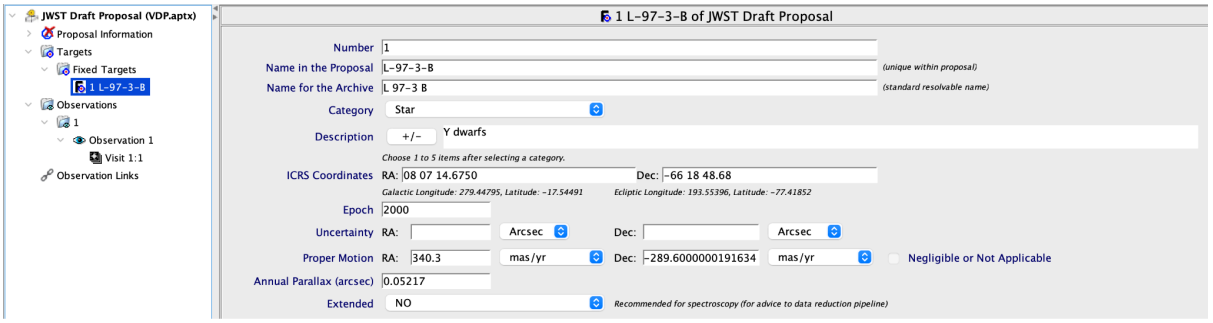
Then save and go back to the “Calculation” Tab. Click on “Calculate” then go through the “Images” and “Plot” panel so see the different results. Take a special care at the “SNR (lambda)” plot. You shouldn’t have more than 5 after 5.5 microns.

To correct for that, go to “detector setup” in the top right-hand panel. For LRS slit, we use a dither = 2 to have two different positions in order to subtract the background. Now play with the number of groups and integrations in order to get a SNR that satisfy you.

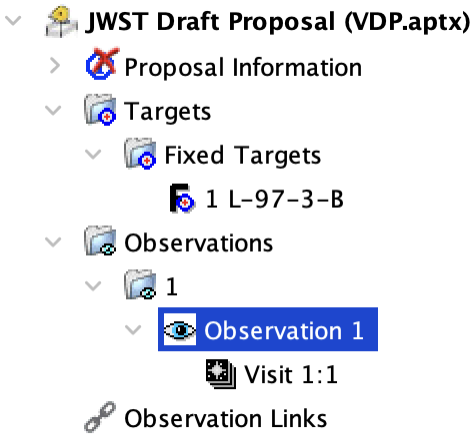
4. APT form

Open the APT (if you did not download it, there it is : https://www.stsci.edu/scientific-community/software/astronomers-proposal-tool-apt/). First of all, know that any blue-written text in the ATP is clickable and send you to the appropriate documentation.
Create new JWST proposal, you can input random title/abstract but we will skip this part for now. In “Targets” click on “fixed target resolver” and search for “L 97-3B” and validate.

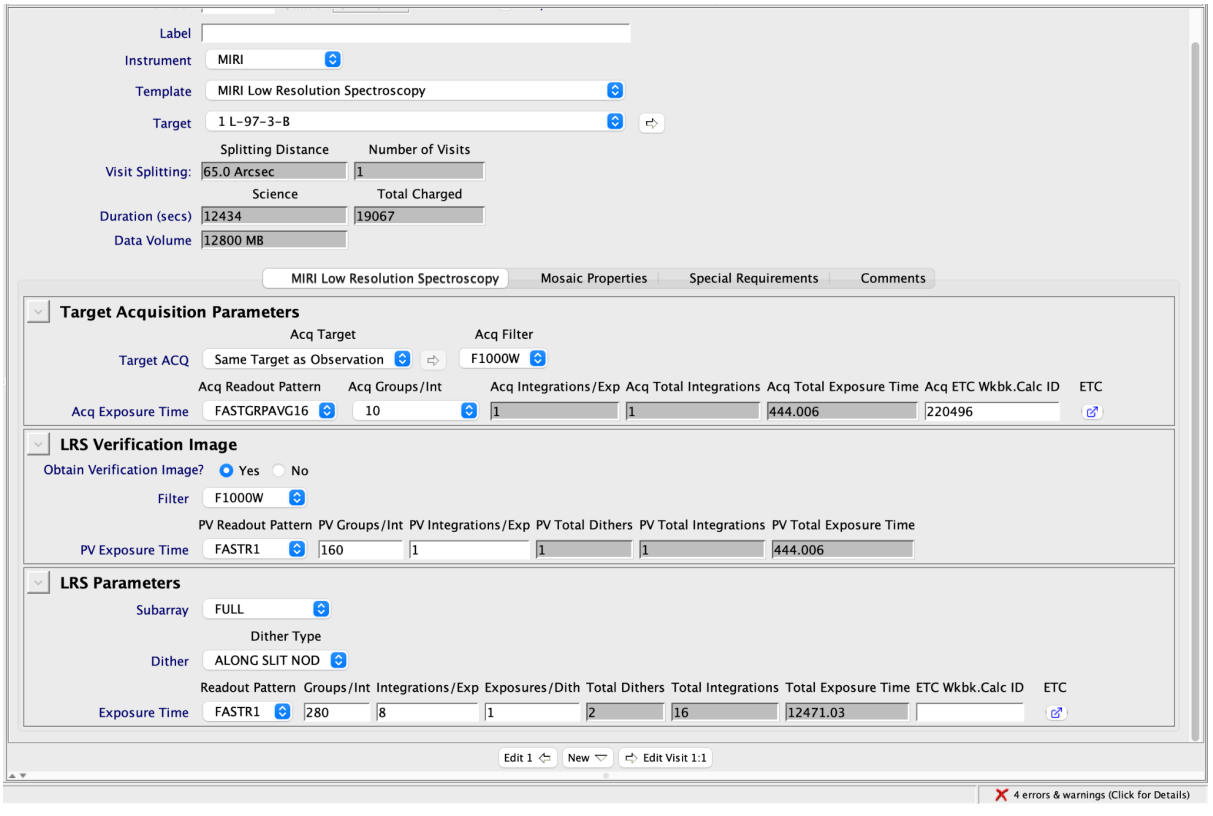
Now go to “1 L-97-3-B” in “fixed targets” and fill the information However, as you pulled it from Simbad most of it is already filled. It is good practice to check it nonetheless.



Now, we move on to the “Observation” panel, add a new one and go in “observation 1”.



Fill out the info as below :



Now for the “Target acquisition parameter” we need to use the ETC! Go back to add to your workbook a MIRI Target Acquisition (TA). Then, with your already defined source, select the proper parameter in “Detector setup” to reach TA without any error when you calculate.

Adding an LRS verification image is not mandatory but recommended. For the parameter of this section, select the same filter as for TA above. Then, play with the groups to have the same exposure time at the end of the line.

Finally, for the LRS parameters, use what you've done in section 3 with the ETC.

5. Forward

For extra documentation : https://jwst-docs.stsci.edu/#gsc.tab=0 , for ETC, APT, pipeline or anything else on JWST.
Also, when starting the ETC on the workbook list, the sample workbook and the example science program workbook are great, very detailed workbook on all instruments and modes.

Of course the STScI help desk if you feel the documentation lacking (not likely but possible, search well).