Neptune: MIRI/MRS Global Map

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Part of GTO1249[1] Programme (PI: Fletcher, using IDS time from H.B. Hammel)

Rationale:

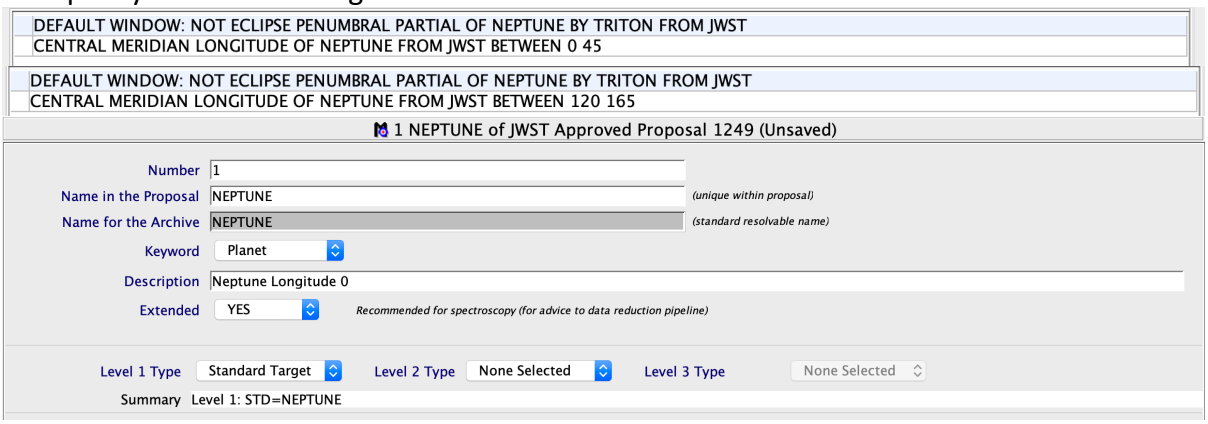
We propose to explore the middle atmospheric circulation of this archetypal ice giant world using spatially-resolved global maps of atmospheric temperatures and tracers of dynamics and chemistry (e.g., hydrocarbon species). With simultaneous multi-wavelength (5-29 µm) spectral imaging, we will: (i) reveal the unusual environmental conditions within Neptune's summer south polar vortex; (ii) search for evidence of vertical coupling between tropospheric storm systems/wind fields and stratospheric dynamics; and (iii) search for evidence of tropical vertical oscillation patterns. JWST results for Neptune and Uranus will be inter-compared to understand the similarities and differences between the two ice giants.

Technique:

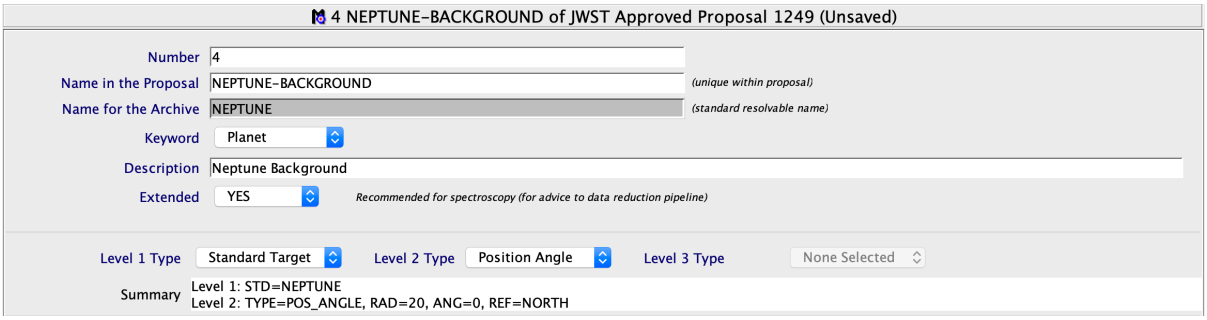
Neptune global spatial-spectral map using MIRI, sampling three longitudes to span 360 degrees. Neptune rotates in 16 hours, 6 minutes. The time between adjacent observations should therefore be 5.4hours. Each longitude has been defined separately to allow the visits to be separated if necessary, but it makes most sense to execute all observations during one 16-hour rotation of Neptune, reducing the need for major slews. If time is unused between the targeted observations, we would welcome extended integration times for these low-signal observations, or NIRSPEC observations identical to those proposed in our complementary Uranus programme (1248).

APT Target:

Precise longitudes are flexible: as long as there is 120 degrees between each MIRI frame. We specify these via a "target window":



[1] http://www.stsci.edu/jwst/observing-programs/program-information?id=1249



MIRI Map:

Observations use a 4-point dither pattern for an extended source, and capture Uranus using all four channels[2] (i.e., the four IFUs) and the three diffraction grating settings within each channel (A-short, B-medium, C-long) to span the 4.9-28.3 µm spectrum. The four channels are observed simultaneously, but only one grating can be used at a time (thus three separated observations are needed for the three grating settings).

Three MIRI observations are specified, each targeting a different longitude (each 120 degrees of longitude apart). A major slew is included at the start of each observation.

Choice of groups: The SHORT detector (channels 1 and 2) show no sign of saturating for 8 groups in the methane band at 7.66 µm (the brightest spectral point from 5-11 µm). The LONG detector (channels 3 and 4) saturate in the 5th group near C2H2 emission at 13.7 µm, so we selected 4 groups.

Choice of dither[3]: MIRI assumes a 4-point dither pattern to optimise the imaging of this 2.3" diameter disc. Large 1" dither offsets should be avoided, as the purpose is to improve spatial sampling for ALL of the MIRI channels. If a 2-point dither pattern appears provide adequate imaging but with a better overall exposure time, then we would consider changing the dithering technique prior to execution.

[2] https://jwst-docs.stsci.edu/mid-infrared-instrument/miri-observing-modes/miri-medium-resolution-spectroscopy
[3] https://jwst-docs.stsci.edu/mid-infrared-instrument/miri-operations/miri-dithering/miri-mrs-dithering

The MIRI science observations required 18078s (5.0hrs) in APTv27.1.1 (June 2019), and this has increased to 21090s (5.9hrs) in APTv2020.1.2 (February 2020). Note that, when we run

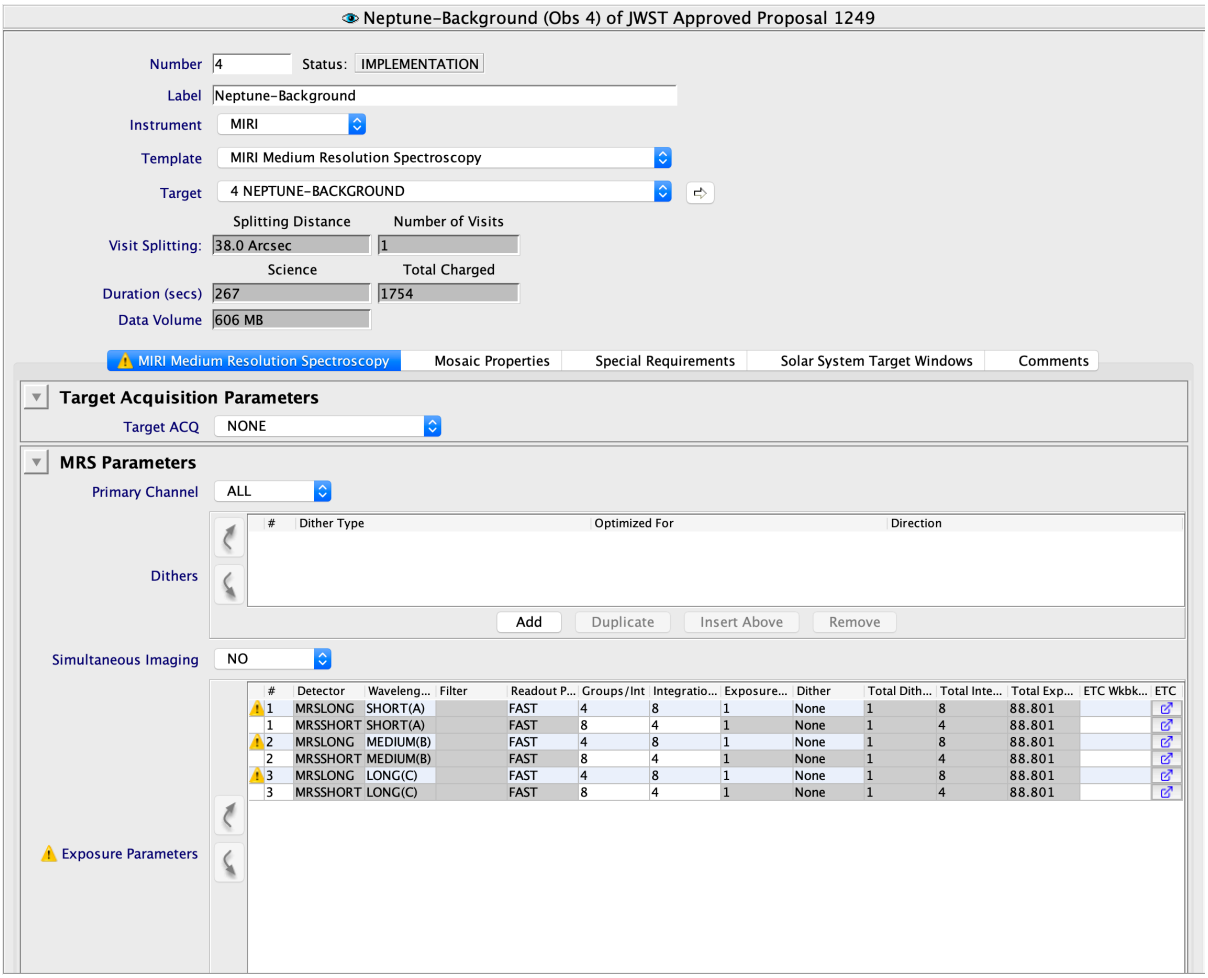
the “visit planner”, extra direct-scheduling overheads (1hr per longitude, 3hrs total) are added to inflate the programme.

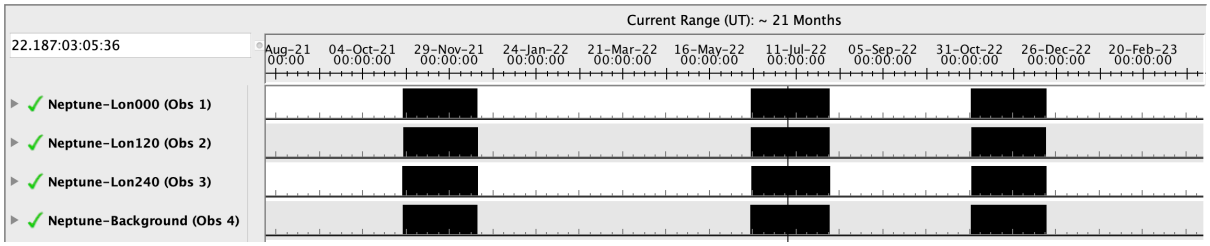
Background Observation:

A calibration frame, targeting blank sky, is desired to subtract spurious contributions to the observations from foreground emission (i.e., thermal emission from the instrument itself and scattered light from the telescope), and also any systematic additive features in the slope images. These may well be bigger in magnitude than the background signal itself, but they will also be different between two different readout cadences. For the small MRS FOV the expectation is that the background will be quite homogeneous, but may change with the epoch of observations. Hence these are designed to have the same groups/integrations as the target observation, but no dither is required, and only a single exposure. The background frame should be taken as close as possible to the target observations (they are linked to occur within 5 hours).

A offset of 20” and zero position angle has been used to define the sky background.

The MIRI calibration observations required 1434s (0.4hrs) in APTv27.1.1 (June 2019), increased to 1754s (0.5hrs) in APTv2020.1.2 (February 2020).





Total time:

The total charged time for the programme was 6.34hrs in APTv2020.1.2 (5.4 hrs in APTv27.1.1), but this inflated by an extra 3 hours with the imposition of “direct scheduling” overhead (1 hour per longitude), exceeding the 6.7 hours allocated.