Uranus: MIRI/MRS and NIRSPEC Global Map

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Part of GTO1247[1] Programme (PI: Fletcher, using IDS time from H.B. Hammel)

Rationale:

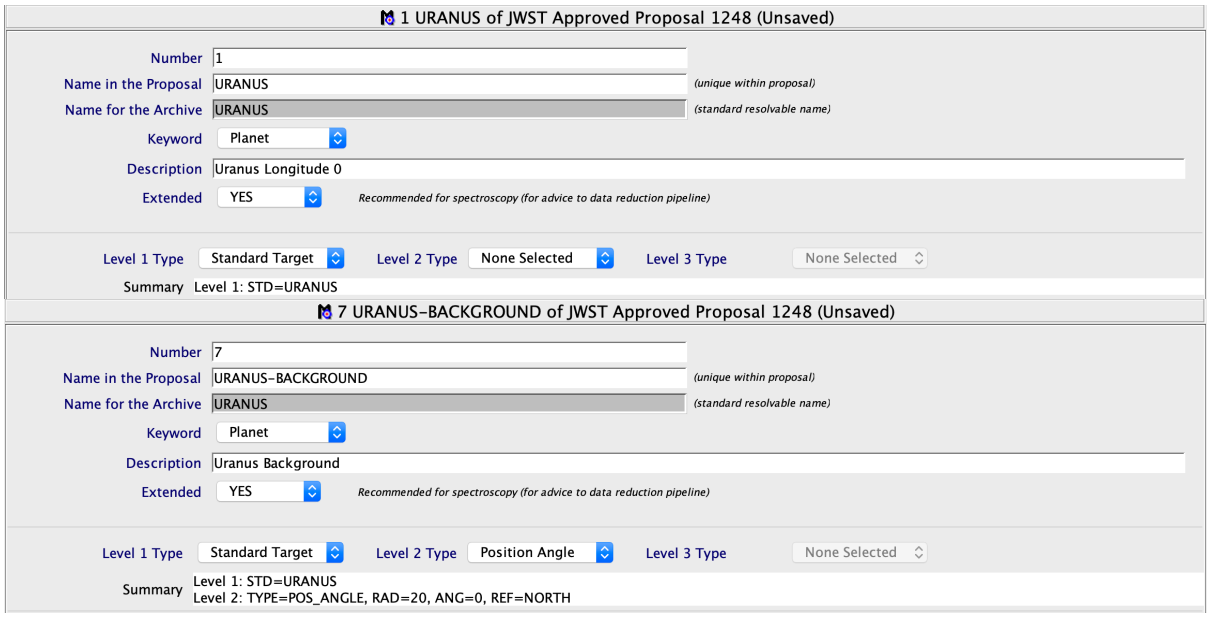
We will investigate the influence of Uranus' extreme seasonal tilt on the circulation and chemistry of this ice giant. Spatially-resolved global spectroscopic maps will reveal contrasts in atmospheric temperatures and chemical tracers (e.g., the myriad hydrocarbons produced via methane photochemistry), as well as a full chemical inventory of this ice giant. MIRI observations will be executed near-simultaneously with NIRSpec observations of uranian H3+, allowing us to understand the coupling between the upper, middle, and lower atmospheric regimes for the first time.

Technique:

Uranus global spatial-spectral map using NIRSpec and MIRI, sampling three longitudes with each instrument to span 360 degrees. Uranus rotates in 17 hours, 14 minutes. The time between adjacent sets (MIRI or NIRSPEC) should therefore be 5.7 hours. 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 17-hour rotation of Uranus, reducing the need for major slews.

APT Target:

Precise longitudes are flexible: as long as there is 120 degrees between each MIRI frame, and 120 degrees between each NIRSPEC frame, then we still sample all 360 degrees of longitude. Indeed, science would be optimised if MIRI and NIRSPEC observations were executed consecutively for a particular longitude. We specify the longitudes via a "target window" constraint, using central meridian longitudes of 0-45, 120-165, and 240-285 degrees.



[1] http://www.stsci.edu/jwst/observing-programs/program-information?id=1248

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).

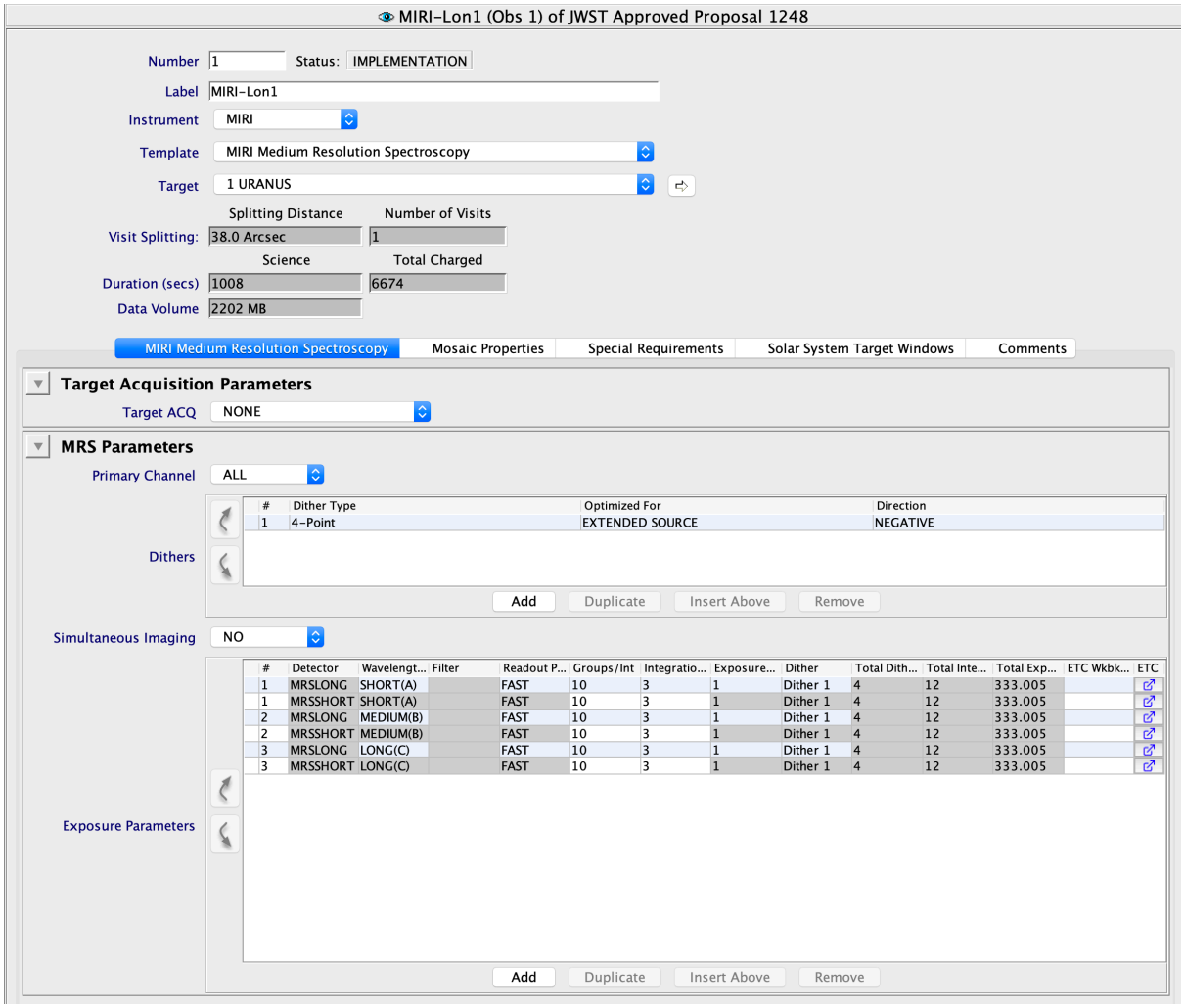
Three MIRI observations are specified, each targeting a different longitude (each 120 degrees of longitude apart). A major slew is included at the start of each observation.

Choice of groups: ETC calculations showed that Uranus will not saturate the detector even with 100 groups, so we compromised and specified 10 groups of 3 integrations.

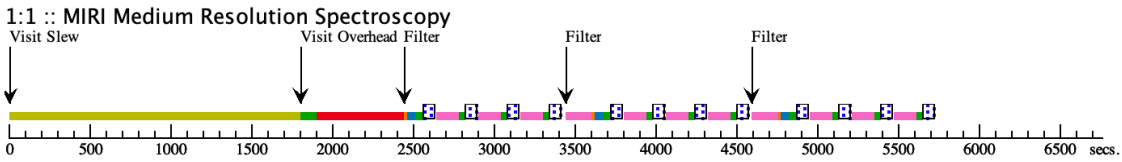
Choice of dither[3]: MIRI assumes a 4-point dither pattern to optimise the imaging of this 3.7" diameter disc. Large 1" dither offsets should be avoided, as the purpose is to improve spatial sampling for ALL of the MIRI channels. If a 2-point dither pattern appears provide adequate imaging but with a better overall exposure time, then we would consider changing the dithering technique prior to execution. NIRSPEC assumed a 4-point dither pattern for the same purpose.

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

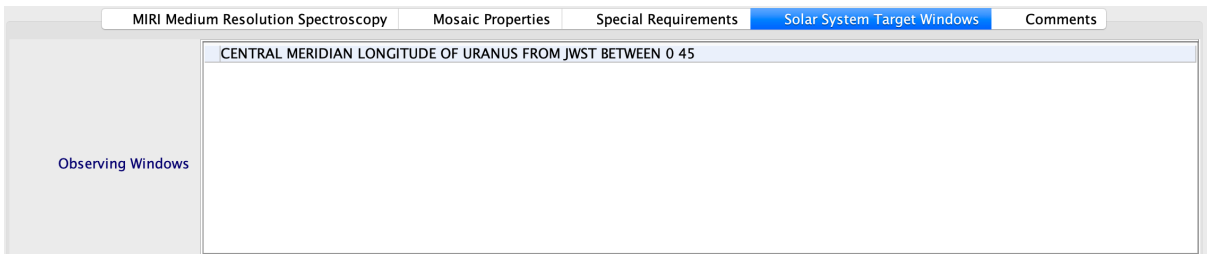
[3] https://jwst-docs.stsci.edu/mid-infrared-instrument/miri-operations/miri-dithering/miri-mrs-dithering



The MIRI science observations required 17730s (4.9hrs) in APTv27.1.1 (June 2019). This increased to 20752s (5.8hrs) in APTv2020.1.2 (February 2020).



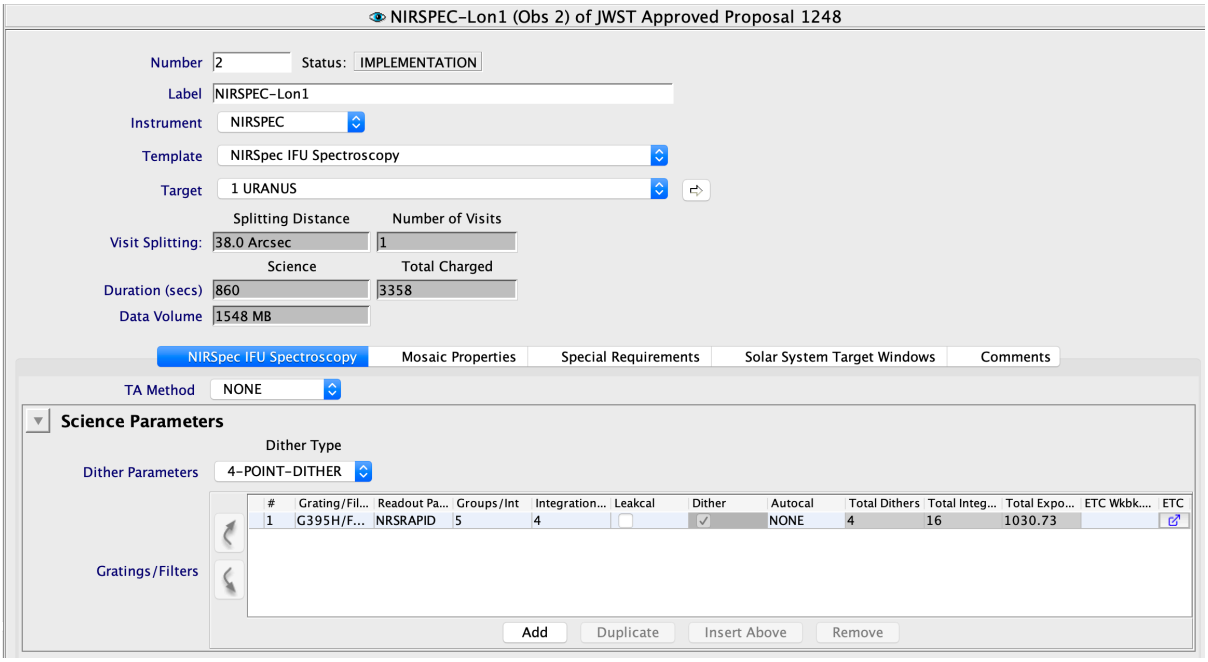
Target windows:



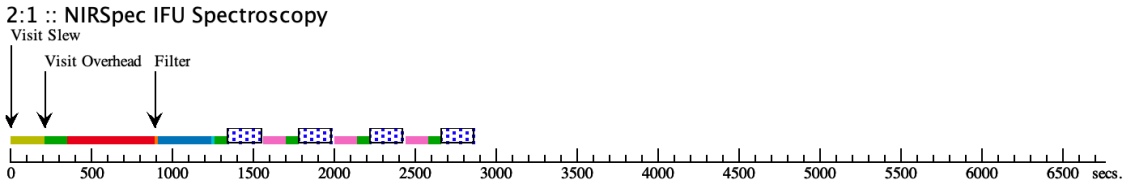
NIRSPEC Map:

The NIRSPEC observations use grating G395H/F290LP[4] (2.9 to 5.3 µm) with a rapid readout mode, 5 groups of 4 integrations, with a 4-point dither pattern. This creates 16 total integrations for each of the maps.

Three NIRSPEC observations are specified, each targeting a different longitude (each 120 degrees of longitude apart). A minor slew is assumed, as JWST will have already pointed to Uranus as part of the MIRI observation.



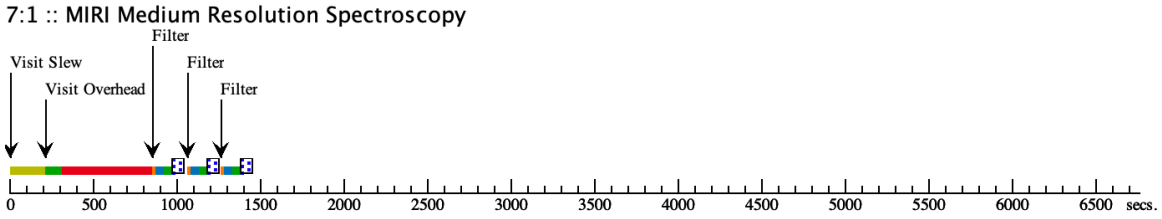
The NIRSPEC observations required 8199s (2.3hrs) in APTv27.1.1 (June 2019). This increased to 10074s (2.8hrs) in APTv2020.1.2 (February 2020).

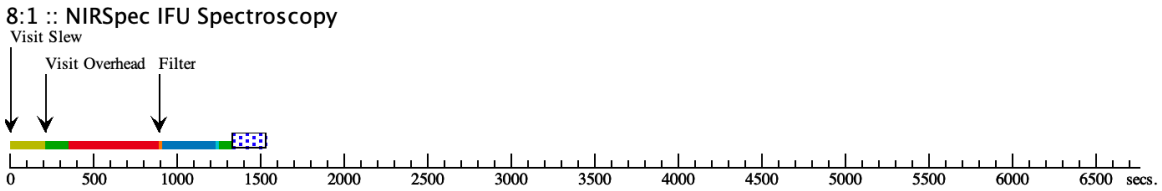


Background Observation:
Both MIRI and NIRSPEC observations assume a single offset to a background region of sky (20" is acceptable, provided no Uranian satellites are in the field of view). This would be best scheduled immediately before or after one of the science exposures. In our APT design, we make these background frames non-interuptable with the final MIRI and NIRSPEC observations (i.e., after the Uranus map is complete).

[4] https://jwst-docs.stsci.edu/near-infrared-spectrograph/nirspec-instrumentation/nirspec-dispersers-and-filters

The MIRI and NIRSPEC background required 1382 and 1408s, respectively, in APTv27.1.1 (June 2019). These increased to 1702 and 1819s in APTv2020.1.2 (February 2020), respectively.





ETC Calculations (v1.1)

Comparison to the MIRI sensitivity model and the ETC suggest Uranus Channels 1-4 will not saturate even with 100 groups, so this was split into multiple integrations of 10 groups to achieve ~5-minute exposure per observation.

Total time:

The total charged time for the programme was 9.54hrs in APTv2020.1.2 (8.0 hrs in APTv27.1.1). This inflates to 11.54 hrs with direct scheduling overhead, but remains within the 13.2hrs allocated. The overhead can be removed if we weaken the central meridian longitude constraint by just 1 degree, returning us to 9.54 hours.