

Uranus: MIRI/MRS and NIRSPEC Global Map

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Part of GTO1247¹ 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 URANUS of JWST Approved Proposal 1248 (Unsaved)	
Number	1
Name in the Proposal	URANUS (unique within proposal)
Name for the Archive	URANUS (standard resolvable name)
Keyword	Planet
Description	Uranus Longitude 0
Extended	YES Recommended for spectroscopy (for advice to data reduction pipeline)
Level 1 Type	Standard Target
Level 2 Type	None Selected
Level 3 Type	None Selected
Summary	Level 1: STD=URANUS

7 URANUS-BACKGROUND of JWST Approved Proposal 1248 (Unsaved)	
Number	7
Name in the Proposal	URANUS-BACKGROUND (unique within proposal)
Name for the Archive	URANUS (standard resolvable name)
Keyword	Planet
Description	Uranus Background
Extended	YES Recommended for spectroscopy (for advice to data reduction pipeline)
Level 1 Type	Standard Target
Level 2 Type	Position Angle
Level 3 Type	None Selected
Summary	Level 1: STD=URANUS Level 2: TYPE=POS_ANGLE, RAD=20, ANG=0, REF=NORTH

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 channels² (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 dither³: 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>

MIRI-Lon1 (Obs 1) of JWST Approved Proposal 1248

Number Status: IMPLEMENTATION

Label

Instrument

Template

Target

Visit Splitting: Number of Visits

Duration (secs) Science Total Charged

Data Volume

MIRI Medium Resolution Spectroscopy Mosaic Properties Special Requirements Solar System Target Windows Comments

Target Acquisition Parameters

Target ACQ

MRS Parameters

Primary Channel

Dithers

#	Dither Type	Optimized For	Direction
1	4-Point	EXTENDED SOURCE	NEGATIVE

Add Duplicate Insert Above Remove

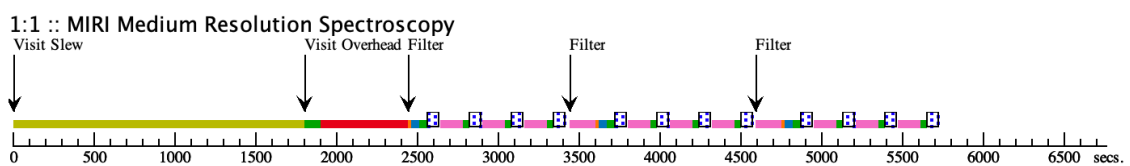
Simultaneous Imaging

#	Detector	Wavelength...	Filter	Readout P...	Groups/Int	Integratio...	Exposure...	Dither	Total Dith...	Total Inte...	Total Exp...	ETC Wkbk...	ETC
1	MRSLONG	SHORT(A)		FAST	10	3	1	Dither 1	4	12	333.005		
1	MRSSHORT	SHORT(A)		FAST	10	3	1	Dither 1	4	12	333.005		
2	MRSLONG	MEDIUM(B)		FAST	10	3	1	Dither 1	4	12	333.005		
2	MRSSHORT	MEDIUM(B)		FAST	10	3	1	Dither 1	4	12	333.005		
3	MRSLONG	LONG(C)		FAST	10	3	1	Dither 1	4	12	333.005		
3	MRSSHORT	LONG(C)		FAST	10	3	1	Dither 1	4	12	333.005		

Add Duplicate Insert Above Remove

Exposure Parameters

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:

MIRI Medium Resolution Spectroscopy Mosaic Properties Special Requirements Solar System Target Windows Comments

Observing Windows

CENTRAL MERIDIAN LONGITUDE OF URANUS FROM JWST BETWEEN 0 45

NIRSPEC Map:

The NIRSPEC observations use grating G395H/F290LP⁴ (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.

NIRSPEC-Lon1 (Obs 2) of JWST Approved Proposal 1248

Number: 2 Status: IMPLEMENTATION

Label: NIRSPEC-Lon1

Instrument: NIRSPEC

Template: NIRSpec IFU Spectroscopy

Target: 1 URANUS

Visit Splitting: 38.0 Arcsec Number of Visits: 1

Duration (secs): 860 Science Total Charged: 3358

Data Volume: 1548 MB

NIRSpec IFU Spectroscopy Mosaic Properties Special Requirements Solar System Target Windows Comments

TA Method: NONE

Science Parameters

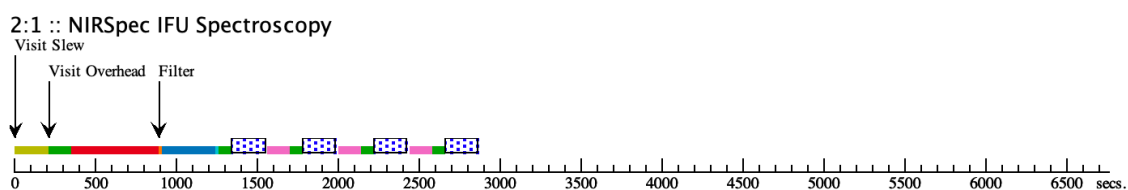
Dither Type: 4-POINT-DITHER

#	Grating/Fil...	Readout Pa...	Groups/Int	Integration...	Leakcal	Dither	Autocal	Total Dithers	Total Integ...	Total Expo...	ETC Wkbk...	ETC
1	G395H/F...	NRSRAPID	5	4		<input checked="" type="checkbox"/>	NONE	4	16	1030.73		

Gratings/Filters

Add Duplicate Insert Above Remove

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).



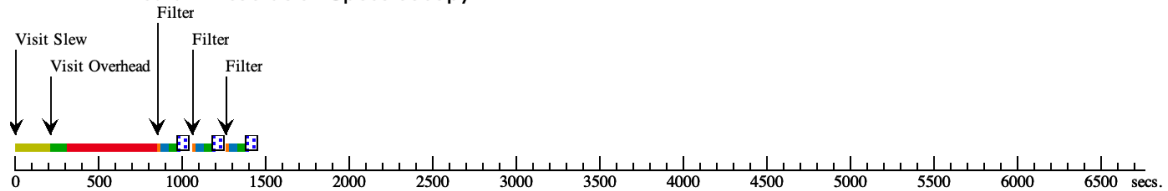
Background Observation:

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-interruptable with the final MIRI and NIRSPEC observations (i.e., after the Uranus map is complete).

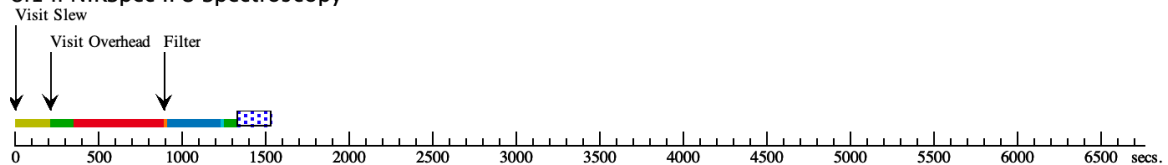
⁴ <https://jwst-docs.stsci.edu/near-infrared-spectrograph/nirspec-instrumentation/nirspec-dispersers-and-filters>

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.

7:1 :: MIRI Medium Resolution Spectroscopy



8:1 :: NIRSPEC IFU Spectroscopy



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.

