

Saturn: MIRI/MRS Summer Hemisphere Scan (&Rings)

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Part of GTO1247¹ Programme (PIs: Fletcher, using IDS time from H.B. Hammel)

Rationale:

Cassini's long-term exploration of Saturn's seasonal atmosphere concludes in 2017 at northern summer solstice, shortly before JWST's launch. We propose observations that establish a baseline for continuing time-domain observations of the planet, rings and satellites: spectra of faint targets in the Saturn system using JWST's unprecedented sensitivity; cross-calibration of JWST instruments with the instruments on board the Cassini spacecraft; and a test of procedures for JWST observations of faint targets near bright objects. Observations include a reconnaissance of the Saturn system with NIRCам, NIRSpec, and MIRI. A mosaic of Saturn's north polar region using MIRI spectro-spatial imaging (5-16 μm) will explore the continued evolution of the polar temperatures, aerosols and composition, including (i) the expected growth of a wide, hot summer vortex in the stratosphere; (ii) variability within the polar cyclones associated with ammonia, phosphine and aerosols; and (iii) identification of any unique polar chemicals/haze species inaccessible to Cassini in the 5.5-7.5 μm region. Deep spectra of selected small moons of Saturn (Epimetheus, Pandora, Pallene, and Telesto) with NIRSpec will test the capacity of JWST to take deep spectra of faint targets near a bright planet. Spectra of Saturn's main rings with MIRI will test the capacity of JWST to take spatially resolved thermal spectra of icy ring systems and will fill a wavelength gap between Cassini VIMS and CIRS.

Technique:

We test the ability of JWST to create a mosaic of an extended, bright, moving, and rotating object by defining three positions on Saturn (Saturn's north pole, and stepping down the central meridian towards the equator), and a fourth point on Saturn's rings. This is different to a specific MIRI mosaic. It is hoped that the scan (along with the 2-point dither pattern) will capture Saturn's summer hemisphere in its entirety. Three overlapping footprints (based on the smallest MRS FOV) target the northern summer hemisphere. Top priority is a direct view of the northern summer pole and hexagon; secondary priority is to step along the prime meridian towards the equator, third priority is the Saturn ring observation.

APT Target:

Three dummy longitudes have been specified in APT assuming 1 hour (36 degrees of Saturn rotation) between footprints; L0; L0+36; L0+72; where the value of L0 can take on any value. Instead of a mosaic, we have targeted three different latitudes (80N, 45N and 15N), and hope that these observations can be executed consecutively. A fourth point in the MIRI observation sequence then offsets to capture Saturn's main rings, using the torus definition of the observation.

¹ <http://www.stsci.edu/jwst/observing-programs/program-information?id=1247>

M 1 SATURN-80N of JWST Approved Proposal 1247 (Unsaved)	
Number	1
Name in the Proposal	SATURN-80N <small>(unique within proposal)</small>
Name for the Archive	SATURN <small>(standard resolvable name)</small>
Keyword	Planet
Description	Saturn's North Pole
Extended	YES <small>Recommended for spectroscopy (for advice to data reduction pipeline)</small>
Level 1 Type	Standard Target
Level 2 Type	Planetographic
Level 3 Type	None Selected
Summary	Level 1: STD=SATURN Level 2: TYPE=PGRAPHIC, LONG=30, LAT=80
Background Target Observations of this target require companion background observation(s) <input type="checkbox"/>	
Comments	Mosaic MIRI MRS observation of Saturn's north pole. The longitude is not important and has been included only as a placeholder.

M 600 SATURN-RINGS of JWST Approved Proposal 1247 (Unsaved)	
Number	600
Name in the Proposal	SATURN-RINGS <small>(unique within proposal)</small>
Name for the Archive	SATURN <small>(standard resolvable name)</small>
Keyword	Ring
Description	Saturn's Main Rings
Extended	Unknown <small>Recommended for spectroscopy (for advice to data reduction pipeline)</small>
Level 1 Type	Standard Target
Level 2 Type	Torus
Level 3 Type	None Selected
Summary	Level 1: STD=SATURN Level 2: TYPE=TORUS, LONG=90, LAT=0, RAD=105000, POLE_LONG=0, POLE_LAT=+90, O_LONG=0, O_LAT=0, O_RAD=0

MIRI Mosaic:

Observations use a 4-point dither pattern for an extended source, and capture Saturn 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).

Choice of groups: ETC calculations show that the 5-16 μm range is accessible without saturation using only two groups to sample up the ramp. However, later interactions with the MIRI team highlighted concerns about the ability to calibrate with such a small number, and there was a strong recommendation to increase to a minimum of 4 groups, even though some of the later groups would be saturated. A commissioning activity is planned to verify the optimum number of groups per integration to use for bright targets, and could hopefully be used to optimise the proposed GTO observations. For the time being, we retain the ability to read out more groups (and use only those up to saturation for analysis. There will be an efficiency hit from throwing away a lot of saturated data, but the low quality of ramps derived from only 2 frames almost certainly eliminates and outweighs this benefit.

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

Choice of dither³: A 4-point dither has been assumed to optimise imaging quality across Channels 1-2, but as we hope to optimise over the full field of view, only small dither steps are required (large 1" dither steps would not work, as this would render only a small area of the FOV optimised). If the 2-point dither pattern turns out to be more suitable, we request to be able to make this change as it would increase the exposure time on target (reducing overheads).

Saturn North Pole MIRI (Obs 612) of JWST Approved Proposal 1247

Number612Status: IMPLEMENTATION

LabelSaturn North Pole MIRI

InstrumentMIRI

TemplateMIRI Medium Resolution Spectroscopy

Target1 SATURN-80N

Splitting Distance38.0 Arcsec

Number of Visits1

Science

Total Charged6744

Duration (secs)1068

Data Volume2336 MB

MIRI Medium Resolution SpectroscopyMosaic PropertiesSpecial RequirementsSolar System Target WindowsComments

Target Acquisition Parameters

Target ACQNONE

MRS Parameters

Primary ChannelALL

Dithers

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

AddDuplicateInsert AboveRemove

Simultaneous ImagingNO

#	Detector	Wavelength...	Filter	Readout P...	Groups/Int	Integratio...	Exposure...	Dither	Total Dith...	Total Inte...	Total Exp...	ETC Wkbk...	ETC
1	MRSLONG	SHORT(A)		FAST	4	8	1	Dither 1	4	32	355.205		
1	MRSSHORT	SHORT(A)		FAST	4	8	1	Dither 1	4	32	355.205		
2	MRSLONG	MEDIUM(B)		FAST	4	8	1	Dither 1	4	32	355.205		
2	MRSSHORT	MEDIUM(B)		FAST	4	8	1	Dither 1	4	32	355.205		
3	MRSLONG	LONG(C)		FAST	4	8	1	Dither 1	4	32	355.205		
3	MRSSHORT	LONG(C)		FAST	4	8	1	Dither 1	4	32	355.205		

AddDuplicateInsert AboveRemove

Exposure Parameters

Note that the observatory overheads increased from APT v27.1.1 (June 2019) to APT 2020.1.2 (February 2020), increasing the Saturn atmosphere and rings observation from 19334s (5.4hrs) to 23288s (6.5hrs, this includes two major 1800s slews, one to the north pole, and one to the rings), and the background frame from 1399s (0.4hrs) to 1720s (0.5hrs).

Note: central meridian timing windows had been removed from APT do that the visit planner would actually work.

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

ETC Calculations (v1.1)

The SHORT detectors (Channel 1 and 2) only saturate with $n_{\text{groups}} > 4$, so we have specified 4 groups. For the LONG detectors (Channels 3 and 4), saturation can only be avoided with 2 groups.

Total Time:

The Saturn atmosphere and rings MIRI observations (plus the background) account for 7 hours of the GTO programme (which also includes NIRCAM and NIRSPEC observations of the satellites). APTv2020.1.2 reports 14.3 hours (before any changes by M. Tiscareno for the satellite programme). APTv2020.2 reduced this time somewhat to 13.8 hours.



