



9609 - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovolcanism

Cycle: 5, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
NIRSpec				
	1	Makemake NIRSpec phase 0	NIRSpec IFU Spectroscopy	(1) Makemake
	2	Makemake NIRSpec phase 120	NIRSpec IFU Spectroscopy	(1) Makemake
	3	Makemake NIRSpec phase 240	NIRSpec IFU Spectroscopy	(1) Makemake
MIRI				
	4	Makemake MIRI phase 0	MIRI Imaging	(1) Makemake

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
	5	Makemake MIRI phase 120	MIRI Imaging	(1) Makemake
	6	Makemake MIRI phase 240	MIRI Imaging	(1) Makemake

ABSTRACT

Previous JWST observations of Makemake, one of the largest trans-Neptunian dwarf planets, revealed two extraordinary discoveries: a mid-infrared thermal excess at 150 K—far above equilibrium expectations—and methane fluorescence, making it only the second trans-Neptunian object, after Pluto, with confirmed gas-phase material. These anomalies may be linked, with a localized hot spot venting methane gas, which would constitute direct evidence for subsurface upwelling and possibly cryovolcanism. Sustaining ~ 150 K requires endogenic heating—either mobilization of primordial methane by radiogenic heat or internal generation via hydrothermal or metamorphic processes. The hotspot’s temperature and size, together with methane production rates from fluorescence, provide quantitative constraints on the scale and persistence of this activity, placing Makemake in context with other active icy worlds such as Enceladus and Triton. However, because current observations were obtained at different epochs and longitudes, they cannot establish whether the two anomalies share a common origin. We therefore propose coordinated NIRSpec and MIRI observations at multiple rotational phases. Coherent modulation of both methane emission and mid-infrared flux excess with longitude would uniquely identify a single venting source, while divergent variability would reveal multiple coexisting processes. Either outcome offers a decisive test of geologic activity and volatile evolution beyond Neptune.

OBSERVING DESCRIPTION

We request coordinated NIRSpec IFU and MIRI imaging observations of Makemake during Cycle 5 to directly test the hypothesized link between its methane emission and mid-infrared thermal excess. Observations will be obtained at three rotational phases separated by 120° , assuming a 22.8266 hr rotation period, which ensures complete longitudinal coverage under either the single-peaked (11.4 hr) or double-peaked solution. This strategy provides a robust test of spatial variability while also enabling comparison with previous JWST epochs to assess temporal evolution.

For NIRSpec, we will use the IFU with the G395H grating ($R \sim 2700$) to isolate individual methane fluorescence lines and discriminate between a tenuous atmosphere and an expanding coma. Achieving the required SNR of ~ 16 per resolution element at $3.346 \mu\text{m}$ (5-sigma detection of model differences) requires 67 groups per integration, 2 integrations per exposure, and the standard 4-point dither pattern with the NRSIRS2RAPID readout. Data will be processed through the JWST Calibration Pipeline, with spectra extracted via PSF fitting and validated by aperture extraction.

JWST Proposal 9609 (Created: Monday, March 16, 2026, 10:00:13AM Eastern Standard Time) - Overview

For MIRI, we will obtain imaging with the F1800W and F2550W filters and measure relative fluxes, which are diagnostic of the thermal excess. The observation design mirrors the Cycle 1 GTO program, with the same readout method, dither strategy, and exposure times, delivering SNR ~ 50 at 18 μm and ~ 30 at 25 μm . These measurements will constrain the hot-spot temperature and radius via thermal modeling at each longitude, even if the thermal excess has diminished since Cycle 1.

Together, the combined dataset will determine whether methane emission and thermal flux modulate coherently with longitude—a result that would uniquely identify an active vent—or vary independently, demonstrating that multiple processes coexist on Makemake.

Proposal 9609 - Targets - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovolcanism

Solar System Targets	#	Name	Level 1	Level 2	Level 3
	(1)	Makemake	STD=MAKEMAKE		
<i>Comments: Extended=NO</i>					

Proposal 9609 - Observation 1 - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovo...

Mon Mar 16 15:00:13 GMT 2026

Observation	Proposal 9609, Observation 1: Makemake NIRSpec phase 0 Diagnostic Status: Warning Observing Template: NIRSpec IFU Spectroscopy											
	(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Makemake NIRSpec phase 0 (Obs 1)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Diagnostics												
Solar System Targets	#	Name	Level 1			Level 2			Level 3			
	(1)	Makemake	STD=MAKEMAKE									
Comments: Extended=NO												
Template	TA Method						HFF Readout Mode					
	NONE						false					
Dithers	#	Dither Type		Size		Starting Point		Number of Points		Points		
	1	4-POINT-DITHER										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	G395H/F290LP	NRSIRS2RAPID	67	2	false	true	NONE	4	8	7936.356	
Special Requirements	Phase -0.10 to 0.0 with period 22.8266 Hours and zero-phase 2459974.5138889 HJD											
	Sequence Observations 1, 4, Non-interruptible Group Observations 1, 2, 3, 4, 5, 6 within 5 Days DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075											

Proposal 9609 - Observation 2 - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovo...

Mon Mar 16 15:00:13 GMT 2026

Observation	<p>Proposal 9609, Observation 2: Makemake NIRSpec phase 120</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
	<p>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Makemake NIRSpec phase 120 (Obs 2)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>											
Diagnostics												
Solar System Targets	#	Name	Level 1			Level 2			Level 3			
	(1)	Makemake	STD=MAKEMAKE									
<p><i>Comments: Extended=NO</i></p>												
Template	TA Method						HFF Readout Mode					
	NONE						false					
Dithers	#	Dither Type		Size	Starting Point			Number of Points	Points			
	1	4-POINT-DITHER										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	G395H/F290LP	NRSIRS2RAPID	67	2	false	true	NONE	4	8	7936.356	
Special Requirements	<p>Phase 0.23 to 0.33 with period 22.8266 Hours and zero-phase 2459974.5138889 HJD</p> <p>Sequence Observations 2, 5, Non-interruptible</p> <p>Group Observations 1, 2, 3, 4, 5, 6 within 5 Days</p> <p>DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075</p>											

Proposal 9609 - Observation 3 - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovo...

Mon Mar 16 15:00:13 GMT 2026

Observation	Proposal 9609, Observation 3: Makemake NIRSpec phase 240 Diagnostic Status: Warning Observing Template: NIRSpec IFU Spectroscopy											
	(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Makemake NIRSpec phase 240 (Obs 3)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Diagnosics												
Solar System Targets	#	Name	Level 1			Level 2			Level 3			
	(1)	Makemake	STD=MAKEMAKE									
Comments: Extended=NO												
Template	TA Method						HFF Readout Mode					
	NONE						false					
Dithers	#	Dither Type		Size		Starting Point		Number of Points		Points		
	1	4-POINT-DITHER										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	G395H/F290LP	NRSIRS2RAPID	67	2	false	true	NONE	4	8	7936.356	
Special Requirements	Phase 0.57 to 0.67 with period 22.8266 Hours and zero-phase 2459974.5138889 HJD											
	Sequence Observations 3, 6, Non-interruptible Group Observations 1, 2, 3, 4, 5, 6 within 5 Days DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075											

Proposal 9609 - Observation 4 - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovo...

Mon Mar 16 15:00:13 GMT 2026

Observation	Proposal 9609, Observation 4: Makemake MIRI phase 0 Diagnostic Status: Warning Observing Template: MIRI Imaging										
	(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Makemake MIRI phase 0 (Obs 4)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.										
Diagnosics											
Solar System Targets	#	Name	Level 1	Level 2	Level 3						
	(1)	Makemake	STD=MAKEMAKE								
<i>Comments: Extended=NO</i>											
Template	Subarray										
	FULL										
Dithers	#	Dither Type	Starting Point	Number of Points	Points	Starting Set	Number of Sets	Optimized For	Direction	Pattern Size	
	1	2-Point								DEFAULT	
Spectral Elements	#	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	F1800W	FASTR1	60	3	1	Dither 1	2	6	1010.115	
	2	F2550W	FASTR1	20	9	1	Dither 1	2	18	1043.415	
Special Requirements	Sequence Observations 1, 4, Non-interruptible Group Observations 1, 2, 3, 4, 5, 6 within 5 Days DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075										

Proposal 9609 - Observation 5 - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovo...

Mon Mar 16 15:00:13 GMT 2026

Observation	Proposal 9609, Observation 5: Makemake MIRI phase 120 Diagnostic Status: Warning Observing Template: MIRI Imaging										
	(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Makemake MIRI phase 120 (Obs 5)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.										
Solar System Targets	#	Name	Level 1			Level 2			Level 3		
	(1)	Makemake	STD=MAKEMAKE								
Comments: Extended=NO											
Template	Subarray										
	FULL										
Dithers	#	Dither Type	Starting Point	Number of Points	Points	Starting Set	Number of Sets	Optimized For	Direction	Pattern Size	
	1	2-Point								DEFAULT	
Spectral Elements	#	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	F1800W	FASTR1	60	3	1	Dither 1	2	6	1010.115	
	2	F2550W	FASTR1	20	9	1	Dither 1	2	18	1043.415	
Special Requirements	Sequence Observations 2, 5, Non-interruptible Group Observations 1, 2, 3, 4, 5, 6 within 5 Days DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075										

Proposal 9609 - Observation 6 - Exploring the Link between Makemake's Thermal Anomaly and Gas Production as a Probe of Cryovo...

Mon Mar 16 15:00:13 GMT 2026

Observation	Proposal 9609, Observation 6: Makemake MIRI phase 240 Diagnostic Status: Warning Observing Template: MIRI Imaging										
	(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Makemake MIRI phase 240 (Obs 6)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.										
Diagnosics											
Solar System Targets	#	Name	Level 1	Level 2	Level 3						
	(1)	Makemake	STD=MAKEMAKE								
<i>Comments: Extended=NO</i>											
Template	Subarray										
	FULL										
Dithers	#	Dither Type	Starting Point	Number of Points	Points	Starting Set	Number of Sets	Optimized For	Direction	Pattern Size	
	1	2-Point								DEFAULT	
Spectral Elements	#	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	F1800W	FASTR1	60	3	1	Dither 1	2	6	1010.115	
	2	F2550W	FASTR1	20	9	1	Dither 1	2	18	1043.415	
Special Requirements	Sequence Observations 3, 6, Non-interruptible Group Observations 1, 2, 3, 4, 5, 6 within 5 Days DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075										