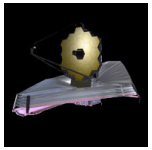

9453 - Timely Follow-up of Newly Discovered Methane Fluorescence on Makemake to Investigate Its Origin and Variability

Cycle: 4, Proposal Category: DD

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Makemake NIRSpec				
	1	Makemake phase 0	NIRSpec IFU Spectroscopy	(1) Makemake
	4	Makemake phase 0 back	NIRSpec IFU Spectroscopy	(2) Makemake-bck
	2	Makemake phase 120	NIRSpec IFU Spectroscopy	(1) Makemake
	5	Makemake phase 120 bck	NIRSpec IFU Spectroscopy	(2) Makemake-bck
	3	Makemake phase 240	NIRSpec IFU Spectroscopy	(1) Makemake
	6	Makemake phase 240 bck	NIRSpec IFU Spectroscopy	(2) Makemake-bck
	13	Makemake phase 240 repeat	NIRSpec IFU Spectroscopy	(1) Makemake
	16	Makemake phase 240 bck repeat	NIRSpec IFU Spectroscopy	(2) Makemake-bck

ABSTRACT

Recent analysis of NIRSpec observations of the dwarf planet Makemake has revealed the unexpected detection of methane gas fluorescence, making Makemake only the second trans-Neptunian object, after Pluto, with confirmed evidence of gaseous volatiles. This discovery raises fundamental questions about the origin of the emission, which can be equally well explained by a gravitationally bound atmosphere or an expanding coma driven by sublimation or cryovolcanic activity. Independent measurements have hinted at possible cryovolcanism on Makemake. If the emission is cryovolcanic in origin (i.e., plume-like activity), it may be transient, making timely follow-up essential. The current G395M data lack the spectral resolution and signal-to-noise ratio needed to discriminate between these scenarios. We propose timely follow-up observations with the NIRSpec IFU using the G395H grating, which will resolve individual methane fluorescence lines, allowing us to accurately model the continuum and measure relative line intensities, necessary to distinguish a coma from a bound atmosphere. To probe potential spatial and temporal variability, we request three observations spaced 120 degrees apart in rotational phase, accommodating uncertainty in Makemake's rotation period and ensuring coverage of the same longitude observed in 2023. Given the unknown nature of the phenomenon, early observations are critical. If the methane emission is transient, it may fade before Cycle 5; conversely, a non-detection would place the first constraints on its lifetime. Either outcome will provide unique insight into volatile release and surface–atmosphere interactions on distant icy worlds.

OBSERVING DESCRIPTION

We plan to observe Makemake with the NIRSpec IFU during the earliest observing window within Cycle 4 (2025 Dec 29 - 2026 Feb 24) in order to characterize its gaseous volatile emission while it may still be ongoing. The observations will utilize the G395H grating to yield the highest possible spectral resolution, which will allow us to robustly resolve the individual emission peaks and accurately model the fluorescence signal. The target signal-to-noise ratio per resolution element is 16 at 3.346 microns, which translates to 11 per wavelength element. Following standard practice for solar system object observations, we will use the four-point dither pattern and the NRSIRS2RAPID readout pattern.

Three separate observations are requested to acquire different longitudinal views of Makemake. These visits are scheduled at 0, 120, and 240 degrees phase assuming a 22.8266 hr rotational period, with the additional timing constraint that the three observations take place within five days. This will allow us to disentagle longitudinal variability from possible temporal variations in the volatile production.

Solar System Targets

#	Name	Level 1	Level 2	Level 3
(1)	Makemake	STD=MAKEMAKE		
Comments: Extended=NO				
(2)	Makemake-bck	STD=MAKEMAKE	TYPE=POS_ANGLE,RAD=60,ANG=0,REF=NORTH	
Comments: Extended=Unknown				

Observation

Proposal 9453, Observation 1: Makemake phase 0 Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observations:[Makemake phase 0 back (Obs 4)]

Diagnostics

(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 0 (Obs 1)) 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

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

Before Date 01-MAR-2026:00:00:00
Phase -0.10 to 0.0 with period 22.8266 Hours and zero-phase 2459974.5138889 HJD

Group Observations 1, 2, 3 within 5 Days
Sequence Observations 1, 4, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075

Observation

Proposal 9453, Observation 4: Makemake phase 0 back Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observation For: [Makemake phase 0 (Obs 1)]

Diagnostics

(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 0 back (Obs 4)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Solar System Targets

#	Name	Level 1	Level 2	Level 3
(2)	Makemake-bck	STD=MAKEMAKE	TYPE=POS_ANGLE,RAD=60,ANG=0,REF=NORTH	

Comments: Extended=Unknown

Template

TA Method	HFF Readout Mode
NONE	false

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	NONE				

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	1	false	false	NONE	1	1	992.045	

Special Requirements

Before Date 01-MAR-2026:00:00:00

Sequence Observations 1, 4, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE Makemake-bck FROM JWST LESS THAN 0.075

Observation

Proposal 9453, Observation 2: Makemake phase 120 Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observations:[Makemake phase 120 bck (Obs 5)]

Diagnostics

(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 120 (Obs 2)) 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

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

Before Date 01-MAR-2026:00:00:00
Phase 0.23 to 0.33 with period 22.8266 Hours and zero-phase 2459974.5138889 HJD

Group Observations 1, 2, 3 within 5 Days
Sequence Observations 2, 5, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075

Observation

Proposal 9453, Observation 5: Makemake phase 120 bck Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observation For: [Makemake phase 120 (Obs 2)]

Diagnostics

(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 120 bck (Obs 5)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Solar System Targets

#	Name	Level 1	Level 2	Level 3
(2)	Makemake-bck	STD=MAKEMAKE	TYPE=POS_ANGLE,RAD=60,ANG=0,REF=NORTH	

Comments: Extended=Unknown

Template

TA Method	HFF Readout Mode
NONE	false

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	NONE				

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	1	false	false	NONE	1	1	992.045	

Special Requirements

Before Date 01-MAR-2026:00:00:00

Sequence Observations 2, 5, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE Makemake-bck FROM JWST LESS THAN 0.075

Observation

Proposal 9453, Observation 3: Makemake phase 240 Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observations:[Makemake phase 240 bck (Obs 6)]

Diagnostics

(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 240 (Obs 3)) 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

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

Before Date 01-MAR-2026:00:00:00
Phase 0.57 to 0.67 with period 22.8266 Hours and zero-phase 2459974.5138889 HJD

Group Observations 1, 2, 3 within 5 Days
Sequence Observations 3, 6, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075

Observation

Proposal 9453, Observation 6: Makemake phase 240 bck Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observation For: [Makemake phase 240 (Obs 3)]

Diagnostics

(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 240 bck (Obs 6)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Solar System Targets

#	Name	Level 1	Level 2	Level 3
(2)	Makemake-bck	STD=MAKEMAKE	TYPE=POS_ANGLE,RAD=60,ANG=0,REF=NORTH	

Comments: Extended=Unknown

Template

TA Method	HFF Readout Mode
NONE	false

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	NONE				

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	1	false	false	NONE	1	1	992.045	

Special Requirements

Before Date 01-MAR-2026:00:00:00

Sequence Observations 3, 6, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE Makemake-bck FROM JWST LESS THAN 0.075

Observation

Proposal 9453, Observation 13: Makemake phase 240 repeat Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observations:[Makemake phase 240 bck repeat (Obs 16)]

Diagnostics

(Visit 13:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 240 repeat (Obs 13)) 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

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 13, 16, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE MAKEMAKE FROM JWST LESS THAN 0.075

Observation

Proposal 9453, Observation 16: Makemake phase 240 bck repeat Mon May 11 19:00:23 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Background Observation For: [Makemake phase 240 repeat (Obs 13)]

Diagnostics

(Visit 16:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Makemake phase 240 bck repeat (Obs 16)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Solar System Targets

#	Name	Level 1	Level 2	Level 3
(2)	Makemake-bck	STD=MAKEMAKE	TYPE=POS_ANGLE,RAD=60,ANG=0,REF=NORTH	

Comments: Extended=Unknown

Template

TA Method	HFF Readout Mode
NONE	false

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	NONE				

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	1	false	false	NONE	1	1	992.045	

Special Requirements

Sequence Observations 13, 16, Non-interruptible

DEFAULT WINDOW: ANGULAR RATE Makemake-bck FROM JWST LESS THAN 0.075