



# 1549 - The deepest search for rare molecules and isotopologues in planet-forming disks

Cycle: 1, 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>
Observation Folder				
	1	FZ Tau	MIRI Medium Resolution Spectroscopy	(1) V-FZ-TAU
	3	TW Cha	MIRI Medium Resolution Spectroscopy	(2) V-TW-CHA
	4	VZ Cha	MIRI Medium Resolution Spectroscopy	(3) V-VZ-CHA
	6	515 Athalia	MIRI Medium Resolution Spectroscopy	(8) 515-ATHALIA
	5	526 Jena	MIRI Medium Resolution Spectroscopy	(6) 526-JENA

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
	55	526 Jena	MIRI Medium Resolution Spectroscopy	(6) 526-JENA

## ABSTRACT

We propose to obtain deep 4.9-28.4 micron MIRI spectroscopy of three molecule-rich protoplanetary disks, known to show very bright water line emission in their Spitzer spectra. Infrared molecular emission from protoplanetary disks traces material near 1 AU - the terrestrial planet forming region. The deep spectra will be used to search for the rarest molecular species that JWST can detect, including heavy isotopologues of water, as well as important carriers of nitrogen and carbon. We will in particular search for H<sub>2</sub>\_18O to measure the H<sub>2</sub>\_16O/H<sub>2</sub>\_18O ratio in disks and determine whether the oxygen is enriched in the heavier isotopologue as is seen in primitive solar system material. We will also search for warm NH<sub>3</sub> and CH<sub>4</sub> as signposts of a vigorous primordial chemistry in the terrestrial planet-forming region. As the volatility of the molecular carriers of carbon, nitrogen and oxygen determine the amount of each are available for accretion onto planets, these observations will provide a critical comparison to exoplanet atmospheric chemistry.

As a critical and necessary part of this proposal, we will obtain deep spectra of two bright asteroids for the construction of very high signal-to-noise ratio spectral response curves (SRFs). Such empirical SRFs are needed to robustly remove the strong, high-frequency fringes present in MIRI-MRS at the ~20% level, and were similarly critical for calibrating the Spitzer-IRS mid-infrared spectra of protoplanetary disks. Recognizing the importance of conservative fringe removal for other MIRI-MRS programs, we waive the exclusive access period so that other MRS spectra of bright point sources can realize their full scientific potential.

## OBSERVING DESCRIPTION

This is a program to obtain very high signal-to-noise ratio MIRI-MRS spectra of 3 protoplanetary disks known to have very rich molecular emission spectra. The spectra will contain many lines from water, C<sub>2</sub>H<sub>2</sub>, HCN, CH<sub>4</sub>, NH<sub>3</sub>, OH and their isotopologues. We are in particular interested in H<sub>2</sub>18O, which can be used to search for the effects of selective photodissociation of CO, followed by water formation. This mechanism has been proposed to explain the strong oxygen isotope anomaly observed in solar system chondrites.

In order to achieve a required signal-to-noise ratio of 300 or more, especially at the longest wavelengths, the strong MIRI MRS fringes must be removed using empirical standard spectra of bright sources with known spectral shapes, obtained at even higher SNRs. To that end we will observe two bright main belt asteroids, 515 Athalia and 526 Jena. These are known to have spectra with almost no features, and a shape that can be well described by a 210 K blackbody.

## JWST Proposal 1549 (Created: Monday, August 21, 2023 at 5:01:55 PM Eastern Standard Time) - Overview

There are no special requirements on scheduling the asteroid observations to maximize flexibility, but we note that putting them on the schedule early will likely increase their potential use with the community. This may also inform future revisions of the formal MIRI calibration plan, something we have discussed with the MIRI team lead, as well as representatives from the MIRI European Consortium.

Proposal 1549 - Targets - The deepest search for rare molecules and isotopologues in planet-forming disks

	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
<b>Fixed Targets</b>	(1)	V-FZ-TAU	RA: 04 32 31.7640 (68.1323500d) Dec: +24 20 3.00 (24.33417d) Equinox: J2000  <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[Protoplanetary disks]</i>		
	(2)	V-TW-CHA	RA: 10 59 1.0880 (164.7545333d) Dec: -77 22 40.71 (-77.37797d) Equinox: J2000  <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[Protoplanetary disks]</i>		
	(3)	V-VZ-CHA	RA: 11 09 23.7900 (167.3491250d) Dec: -76 23 20.76 (-76.38910d) Equinox: J2000  <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[Protoplanetary disks]</i>		
<b>Solar System Targets</b>	(6)	526-JENA	TYPE=ASTEROID,A=3.124162141469638,E=0.1362 77569246821,I=2.172003277696343 ,O=137.7929696452252,W=357.2536376896855,M=3 28.5345922749213,EQUINOX=J2000,EPOCH=02- JUN-2013:00:00:00,EpochTimeScale=TDB  <i>Comments: Extended=NO</i>	Level 2	Level 3
	(8)	515-ATHALIA	TYPE=ASTEROID,A=3.124532013131975,E=0.1699 185830005238,I=2.038279717297051 ,O=121.2113731671708,W=299.8108344565445,M=1 1.13425759966453,EQUINOX=J2000,EPOCH=04- FEB-2015:00:00:00,EpochTimeScale=TDB  <i>Comments: Extended=Unknown</i>	Level 2	Level 3

Proposal 1549 - Observation 1 - The deepest search for rare molecules and isotopologues in planet-forming disks

Mon Aug 21 22:01:55 GMT 2023

Observation	Proposal 1549, Observation 1: FZ Tau Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous				
	(1)	V-FZ-TAU	RA: 04 32 31.7640 (68.1323500d) Dec: +24 20 3.00 (24.33417d) Equinox: J2000  <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=Star Description=[Protoplanetary disks]										
Acquisition	#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID				
	1	SAME	FND	FAST	4	1	1	11.1	50758.23				
Template	Primary Channel		Simultaneous Imaging			Imager Subarray			Grating Wheel Direction				
	ALL		YES			FULL			NEUTRAL				
Dithers	#	Dither Type			Optimized For			Direction					
	1	4-Point			POINT SOURCE			NEGATIVE					
Spectral Elements	#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1		IMAGER	F770W	FASTR1	14	6	1	Dither 1	4	24	987.914	
	1	SHORT(A)	MRSLONG		FASTR1	21	4	1	Dither 1	4	16	965.714	
	1	SHORT(A)	MRSSHORT		FASTR1	14	6	1	Dither 1	4	24	987.914	
	2		IMAGER	F770W	FASTR1	14	6	1	Dither 1	4	24	987.914	
	2	MEDIUM(B)	MRSLONG		FASTR1	21	4	1	Dither 1	4	16	965.714	
	2	MEDIUM(B)	MRSSHORT		FASTR1	14	6	1	Dither 1	4	24	987.914	
	3		IMAGER	F770W	FASTR1	14	6	1	Dither 1	4	24	987.914	
	3	LONG(C)	MRSLONG		FASTR1	21	4	1	Dither 1	4	16	965.714	
	3	LONG(C)	MRSSHORT		FASTR1	14	6	1	Dither 1	4	24	987.914	

Proposal 1549 - Observation 3 - The deepest search for rare molecules and isotopologues in planet-forming disks

Mon Aug 21 22:01:55 GMT 2023

<b>Observation</b>	<b>Proposal 1549, Observation 3: TW Cha</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 3:1) Warning (Form): Data Excess over lower threshold (Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
<b>Diagnosics</b>													
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>				<b>Targ. Coord. Corrections</b>			<b>Miscellaneous</b>			
	(2)	V-TW-CHA	RA: 10 59 1.0880 (164.7545333d) Dec: -77 22 40.71 (-77.37797d) Equinox: J2000										
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[Protoplanetary disks]</i>													
<b>Acquisition</b>	<b>#</b>	<b>Target</b>	<b>Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>				
	1	SAME	FND	FAST	4	1	1	11.1	50758.24				
<b>Template</b>	<b>Primary Channel</b>			<b>Simultaneous Imaging</b>			<b>Imager Subarray</b>			<b>Grating Wheel Direction</b>			
	ALL			YES			FULL			NEUTRAL			
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>				<b>Optimized For</b>			<b>Direction</b>				
	1	4-Point				POINT SOURCE			NEGATIVE				
<b>Spectral Elements</b>	<b>#</b>	<b>Wavelength Range</b>	<b>Detector</b>	<b>Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Exposures/Dith</b>	<b>Dither</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1		IMAGER	F770W	FASTR1	10	5	1	Dither 1	4	20	599.409	
	1	LONG(C)	MRSLONG		FASTR1	53	4	1	Dither 1	4	16	2386.534	
	1	LONG(C)	MRSSHORT		FASTR1	35	6	1	Dither 1	4	24	2386.534	
	2		IMAGER	F770W	FASTR1	10	5	1	Dither 1	4	20	599.409	
	2	MEDIUM(B)	MRSLONG		FASTR1	53	4	1	Dither 1	4	16	2386.534	
	2	MEDIUM(B)	MRSSHORT		FASTR1	35	6	1	Dither 1	4	24	2386.534	
	3		IMAGER	F770W	FASTR1	10	5	1	Dither 1	4	20	599.409	
	3	SHORT(A)	MRSLONG		FASTR1	53	4	1	Dither 1	4	16	2386.534	
	3	SHORT(A)	MRSSHORT		FASTR1	35	6	1	Dither 1	4	24	2386.534	

Proposal 1549 - Observation 4 - The deepest search for rare molecules and isotopologues in planet-forming disks

Mon Aug 21 22:01:55 GMT 2023

Observation	Proposal 1549, Observation 4: VZ Cha Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous				
	(3)	V-VZ-CHA	RA: 11 09 23.7900 (167.3491250d) Dec: -76 23 20.76 (-76.38910d) Equinox: J2000  <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[Protoplanetary disks]</i>										
Acquisition	#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID				
	1	SAME	FND	FAST	4	1	1	11.1	50758.25				
Template	Primary Channel		Simultaneous Imaging			Imager Subarray			Grating Wheel Direction				
	ALL		YES			FULL			NEUTRAL				
Dithers	#	Dither Type			Optimized For			Direction					
	1	4-Point			POINT SOURCE			NEGATIVE					
Spectral Elements	#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/E xp	Exposures/Dit h	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1		IMAGER	F770W	FASTR1	10	5	1	Dither 1	4	20	599.409	
	1	LONG(C)	MRSLONG		FASTR1	38	4	1	Dither 1	4	16	1720.525	
	1	LONG(C)	MRSSHORT		FASTR1	19	8	1	Dither 1	4	32	1764.925	
	2		IMAGER	F770W	FASTR1	10	5	1	Dither 1	4	20	599.409	
	2	MEDIUM(B)	MRSLONG		FASTR1	39	4	1	Dither 1	4	16	1764.925	
	2	MEDIUM(B)	MRSSHORT		FASTR1	19	8	1	Dither 1	4	32	1764.925	
	3		IMAGER	F770W	FASTR1	10	5	1	Dither 1	4	20	599.409	
	3	SHORT(A)	MRSLONG		FASTR1	38	4	1	Dither 1	4	16	1720.525	
	3	SHORT(A)	MRSSHORT		FASTR1	19	8	1	Dither 1	4	32	1764.925	

Proposal 1549 - Observation 6 - The deepest search for rare molecules and isotopologues in planet-forming disks

Mon Aug 21 22:01:55 GMT 2023

<b>Observation</b>	Proposal 1549, Observation 6: 515 Athalia Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (515 Athalia (Obs 6)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.												
<b>Solar System Targets</b>	#	Name	Level 1				Level 2				Level 3		
	(8)	515-ATHALIA	TYPE=ASTEROID,A=3.124532013131975,E=0.1699 185830005238,I=2.038279717297051 ,O=121.2113731671708,W=299.8108344565445,M=1 1.13425759966453,EQUINOX=J2000,EPOCH=04- FEB-2015:00:00:00,EpochTimeScale=TDB Comments: Extended=Unknown										
<b>Acquisition</b>	#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID				
	1	SAME	FND	FAST	4	1	1	11.1	50758.13				
<b>Template</b>	Primary Channel		Simultaneous Imaging			Imager Subarray			Grating Wheel Direction				
	ALL		YES			FULL			NEUTRAL				
<b>Dithers</b>	#	Dither Type				Optimized For			Direction				
	1	4-Point				POINT SOURCE			NEGATIVE				
<b>Spectral Elements</b>	#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	1	LONG(C)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	1	LONG(C)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	
	2		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	2	MEDIUM(B)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	2	MEDIUM(B)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	
	3		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	3	SHORT(A)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	3	SHORT(A)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	



Proposal 1549 - Observation 6 - The deepest search for rare molecules and isotopologues in planet-forming disks

Special Requirements

DEFAULT WINDOW: ANGULAR RATE 515-ATHALIA FROM JWST LESS THAN 0.03

Proposal 1549 - Observation 5 - The deepest search for rare molecules and isotopologues in planet-forming disks

Mon Aug 21 22:01:55 GMT 2023

<b>Observation</b>	Proposal 1549, Observation 5: 526 Jena Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (526 Jena (Obs 5)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.												
<b>Solar System Targets</b>	#	Name	Level 1				Level 2				Level 3		
	(6)	526-JENA	TYPE=ASTEROID,A=3.124162141469638,E=0.1362 77569246821,I=2.172003277696343 ,O=137.7929696452252,W=357.2536376896855,M=3 28.5345922749213,EQUINOX=J2000,EPOCH=02- JUN-2013:00:00:00,EpochTimeScale=TDB Comments: Extended=NO										
<b>Acquisition</b>	#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID				
	1	SAME	FND	FAST	4	1	1	11.1	50758.13				
<b>Template</b>	Primary Channel		Simultaneous Imaging			Imager Subarray			Grating Wheel Direction				
	ALL		YES			FULL			NEUTRAL				
<b>Dithers</b>	#	Dither Type				Optimized For				Direction			
	1	4-Point				POINT SOURCE				NEGATIVE			
<b>Spectral Elements</b>	#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	1	LONG(C)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	1	LONG(C)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	
	2		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	2	MEDIUM(B)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	2	MEDIUM(B)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	
	3		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	3	SHORT(A)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	3	SHORT(A)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	

Proposal 1549 - Observation 5 - The deepest search for rare molecules and isotopologues in planet-forming disks

Special Requirements

DEFAULT WINDOW: ANGULAR RATE 526-JENA FROM JWST LESS THAN 0.03

Proposal 1549 - Observation 55 - The deepest search for rare molecules and isotopologues in planet-forming disks

Mon Aug 21 22:01:55 GMT 2023

<b>Observation</b>	Proposal 1549, Observation 55: 526 Jena Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 55:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (526 Jena (Obs 55)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.												
<b>Solar System Targets</b>	#	Name	Level 1				Level 2				Level 3		
	(6)	526-JENA	TYPE=ASTEROID,A=3.124162141469638,E=0.1362 77569246821,I=2.172003277696343 ,O=137.7929696452252,W=357.2536376896855,M=3 28.5345922749213,EQUINOX=J2000,EPOCH=02- JUN-2013:00:00:00,EpochTimeScale=TDB Comments: Extended=NO										
<b>Acquisition</b>	#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID				
	1	SAME	FND	FAST	4	1	1	11.1	50758.13				
<b>Template</b>	Primary Channel		Simultaneous Imaging			Imager Subarray			Grating Wheel Direction				
	ALL		YES			FULL			NEUTRAL				
<b>Dithers</b>	#	Dither Type				Optimized For			Direction				
	1	4-Point				POINT SOURCE			NEGATIVE				
<b>Spectral Elements</b>	#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	1	LONG(C)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	1	LONG(C)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	
	2		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	2	MEDIUM(B)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	2	MEDIUM(B)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	
	3		IMAGER	F770W	FASTR1	5	13	1	Dither 1	4	52	854.712	
	3	SHORT(A)	MRSLONG		FASTR1	15	5	1	Dither 1	4	20	876.913	
	3	SHORT(A)	MRSSHORT		FASTR1	26	3	1	Dither 1	4	12	888.013	

Proposal 1549 - Observation 55 - The deepest search for rare molecules and isotopologues in planet-forming disks

Special Requirements

DEFAULT WINDOW: ANGULAR RATE 526-JENA FROM JWST LESS THAN 0.03