



# 2368 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenching

Cycle: 1, Proposal Category: GO

## INVESTIGATORS

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Dr. Ryan C. Hickox (CoI)	Dartmouth College
Prof. Gregory Howard Rudnick (CoI)	University of Kansas Center for Research, Inc.
Dr. Serena Perrotta (CoI)	University of California - San Diego
Dr. Aleksandar M. Diamond-Stanic (CoI)	Bates College
Dr. Paul H Sell (CoI)	University of Florida
Dr. Jim Geach (CoI) (ESA Member)	University of Hertfordshire
Prof. David Rupke (CoI)	Rhodes College
Dr. Alison L. Coil (CoI)	University of California - San Diego
Dr. John Moustakas (CoI)	Siena College

## OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
MIRI_J1107				
	1	J1107 Obs	MIRI Medium Resolution Spectroscopy	(1) J1107+0417
MIRI_J1219				
	2	J1219 Obs	MIRI Medium Resolution Spectroscopy	(2) J1219+0336
MIRI_J1506				
	3	J1506 Obs	MIRI Medium Resolution Spectroscopy	(3) J1506+5402
	4	J1506 Back Obs	MIRI Medium Resolution Spectroscopy	(8) J1506-BACKGROUND
MIRI_J1613				

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
	5	J1613 Obs	MIRI Medium Resolution Spectroscopy	(4) J1613+2834
	6	J1613 Back Obs	MIRI Medium Resolution Spectroscopy	(7) J1613-BACKGROUND
MIRI_J2118				
	7	J2118 Obs	MIRI Medium Resolution Spectroscopy	(5) J2118+0017
	8	J2118 Back Obs	MIRI Medium Resolution Spectroscopy	(6) J2118-BACKGROUND

## ABSTRACT

A central problem in astrophysics regards the formation of massive galaxies, which models suggest may be driven by powerful, compact starbursts with energetic feedback. Most massive galaxies form at high redshift ( $z > 3$ ), but astronomers have recently discovered an exceptional low redshift ( $z \sim 0.5$ ) population of massive compact starbursts with powerful ionized and molecular outflows (velocities up to 3000 km/s and radii up to 50 kpc) that provide a unique testbed to observe this process in detail. A wide range of optical, mid-IR, molecular, and radio observations of these galaxies have illustrated their morphologies and the energetics of their outflows, but critical open questions remain that can only be answered with sensitive mid-IR spectroscopy with JWST: Is the powerful feedback driven by star formation or a hidden AGN? What are the precise rates of dust-obscured star formation? And do the galaxies drive outflows even in highly ionized gas? This proposal seeks MIRI medium-resolution spectroscopy of five representative compact starbursts to answer these questions, in order to definitively understand their formation processes and those of typical massive galaxies in the early Universe.

## OBSERVING DESCRIPTION

This is an MIRI medium resolution spectroscopy program to observe 5 compact massive starburst galaxies at  $z=0.4 - 0.6$ . Targets were selected to be bright in WISE W4 and to span a range in W1-W2 color, which is sensitive to obscured AGN activity. The galaxies are very compact and will likely be point sources at MIRI's resolution. However, 3 targets show spatially extended outflows and therefore we require separate background observations for them.

Our sources do not require a target acquisition exposure as standard JWST pointing accuracy is sufficient to place them on the IFU. We will use all of the MRS channels/bands to obtain wavelength coverage from 5-28 microns which corresponds to 3-19  $\mu\text{m}$  in the restframe of the galaxies. We use equal exposure times in all channels/bands to create a uniform dataset. We will use a standard 4-point dither for extended sources and the fast readout mode. We will acquire MIRI imaging in the F1130W filter simultaneously. The galaxies require between 1 - 3 hours of exposure time each (totaled over all three bands and including time for off-scene nods). Observations can be scheduled in a single visit per galaxy.

# Proposal 2368 - Targets - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenching

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous	
(1)	J1107+0417	RA: 11 07 2.8728 (166.7619700d) Dec: +04 17 2.75 (4.28410d) Equinox: J2000	Epoch of Position: 2000		
<i>Comments:</i> Category=Galaxy Description=[Compact galaxies, Starburst galaxies] Extended=YES					
(2)	J1219+0336	RA: 12 19 55.7760 (184.9824000d) Dec: +03 36 15.90 (3.60442d) Equinox: J2000	Epoch of Position: 2000		
<i>Comments:</i> Category=Galaxy Description=[Compact galaxies, Starburst galaxies] Extended=YES					
(3)	J1506+5402	RA: 15 06 36.2976 (226.6512400d) Dec: +54 02 20.74 (54.03909d) Equinox: J2000	Epoch of Position: 2000		
<i>Comments:</i> Category=Galaxy Description=[Compact galaxies, Starburst galaxies] Extended=YES					
Fixed Targets	(4)	J1613+2834	RA: 16 13 32.5248 (243.385200d) Dec: +28 34 14.78 (28.57077d) Equinox: J2000	Epoch of Position: 2000	
	<i>Comments:</i> Using background for off-scene nod Category=Galaxy Description=[Compact galaxies, Starburst galaxies] Extended=YES				
	(5)	J2118+0017	RA: 21 18 24.0624 (319.6002600d) Dec: +00 17 29.43 (.29151d) Equinox: J2000	Epoch of Position: 2000	
	<i>Comments:</i> Using background for off-scene nod Category=Galaxy Description=[Compact galaxies, Starburst galaxies] Extended=YES				
	(6)	J2118-BACKGROUND	RA: 21 18 24.0624 (319.6002600d) Dec: +00 16 29.43 (.27484d) Equinox: J2000	Epoch of Position: 2000	
	<i>Comments:</i> Using background for off-scene nod Category=Unidentified Description=[Blank field] Extended=NO				
	(7)	J1613-BACKGROUND	RA: 16 13 32.5248 (243.385200d) Dec: +28 33 14.78 (28.55411d) Equinox: J2000	Epoch of Position: 2000	
<i>Comments:</i> Using background for off-scene nod Category=Unidentified Description=[Blank field] Extended=YES					

# Proposal 2368 - Targets - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenching

(8)	J1506-BACKGROUND	RA: 15 06 36.2976 (226.6512400d) Dec: +54 01 20.74 (54.02243d) Equinox: J2000	Epoch of Position: 2000
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*Comments:*  
*Category=Unidentified*  
*Description=[Blank field]*  
*Extended=YES*

Proposal 2368 - Observation 1 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

Fri Apr 28 21:00:59 GMT 2023

<b>Observation</b>	<b>Proposal 2368, Observation 1: J1107 Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>				<b>Targ. Coord. Corrections</b>			<b>Miscellaneous</b>			
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<i>Comments:</i> Category=Galaxy Description=[Compact galaxies, Starburst galaxies] Extended=YES													
<b>Acquisition</b>	<b>#</b>	<b>Target</b>											
	1	NONE											
<b>Template</b>	<b>AcqFilter</b>	<b>Primary Channel</b>				<b>Simultaneous Imaging</b>			<b>Imager Subarray</b>				
	FND	ALL				YES			FULL				
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>				<b>Optimized For</b>			<b>Direction</b>				
	1	4-Point				EXTENDED 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/E xp</b>	<b>Exposures/Dit h</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	F1130W	FASTR1	110	2	1	Dither 1	4	8	2453.135	
	1	LONG(C)	MRSLONG		SLOWR1	26	1	1	Dither 1	4	4	2484.552	
	1	LONG(C)	MRSSHORT		SLOWR1	26	1	1	Dither 1	4	4	2484.552	
	2		IMAGER	F1130W	FASTR1	110	2	1	Dither 1	4	8	2453.135	
	2	MEDIUM(B)	MRSLONG		SLOWR1	26	1	1	Dither 1	4	4	2484.552	88829
	2	MEDIUM(B)	MRSSHORT		SLOWR1	26	1	1	Dither 1	4	4	2484.552	
	3		IMAGER	F1130W	FASTR1	110	2	1	Dither 1	4	8	2453.135	
	3	SHORT(A)	MRSLONG		SLOWR1	26	1	1	Dither 1	4	4	2484.552	
	3	SHORT(A)	MRSSHORT		SLOWR1	26	1	1	Dither 1	4	4	2484.552	

Proposal 2368 - Observation 2 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

Fri Apr 28 21:00:59 GMT 2023

<b>Observation</b>	<b>Proposal 2368, Observation 2: J1219 Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
<b>Fixed Targets</b>	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous				
	(2)	J1219+0336	RA: 12 19 55.7760 (184.9824000d) Dec: +03 36 15.90 (3.60442d) Equinox: J2000			Epoch of Position: 2000							
Comments: Category=Galaxy Description=[Compact galaxies, Starburst galaxies] Extended=YES													
<b>Acquisition</b>	#	Target											
	1	NONE											
<b>Template</b>	AcqFilter	Primary Channel			Simultaneous Imaging			Imager Subarray					
	FND	ALL			YES			FULL					
<b>Dithers</b>	#	Dither Type			Optimized For			Direction					
	1	4-Point			EXTENDED 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	F1130W	FASTR1	100	1	1	Dither 1	4	4	1110.016	
	1	LONG(C)	MRSLONG		FASTR1	100	1	1	Dither 1	4	4	1110.016	
	1	LONG(C)	MRSSHORT		FASTR1	100	1	1	Dither 1	4	4	1110.016	
	2		IMAGER	F1130W	FASTR1	100	1	1	Dither 1	4	4	1110.016	
	2	MEDIUM(B)	MRSLONG		FASTR1	100	1	1	Dither 1	4	4	1110.016	54433
	2	MEDIUM(B)	MRSSHORT		FASTR1	100	1	1	Dither 1	4	4	1110.016	
	3		IMAGER	F1130W	FASTR1	100	1	1	Dither 1	4	4	1110.016	
	3	SHORT(A)	MRSLONG		FASTR1	100	1	1	Dither 1	4	4	1110.016	
	3	SHORT(A)	MRSSHORT		FASTR1	100	1	1	Dither 1	4	4	1110.016	

Proposal 2368 - Observation 3 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

Fri Apr 28 21:00:59 GMT 2023

<b>Observation</b>	<b>Proposal 2368, Observation 3: J1506 Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy Background Observations:[J1506 Back Obs (Obs 4)] Comments: We are taking 2 exposures in order to account for time needed for off-scene nodding																																																																																																																																													
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Special Requirements

Sequence Observations 3, 4, Non-interruptible



Proposal 2368 - Observation 4 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

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<b>Observation</b>	<b>Proposal 2368, Observation 4: J1506 Back Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy Background Observation For: [J1506 Obs (Obs 3)] <i>Comments: We are taking 2 exposures in order to account for time needed for off-scene nodding</i>																																																																																																																																													
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Special Requirements

Sequence Observations 3, 4, Non-interruptible

Proposal 2368 - Observation 5 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

Fri Apr 28 21:00:59 GMT 2023

<b>Observation</b>	<b>Proposal 2368, Observation 5: J1613 Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy Background Observations:[J1613 Back Obs (Obs 6)] Comments: Source has large outflow so need off-scene nod (added background exposure for this)																																																																																																																																													
	(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																																																																																																																													
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Special Requirements

Sequence Observations 5, 6, Non-interruptible

Proposal 2368 - Observation 6 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

Fri Apr 28 21:00:59 GMT 2023

<b>Observation</b>	<b>Proposal 2368, Observation 6: J1613 Back Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy Background Observation For: [J1613 Obs (Obs 5)]												
	(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
<b>Fixed Targets</b>	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous				
	(7)	J1613-BACKGROUND	RA: 16 13 32.5248 (243.3855200d) Dec: +28 33 14.78 (28.55411d) Equinox: J2000			Epoch of Position: 2000							
Comments: Using background for off-scene nod Category=Unidentified Description=[Blank field] Extended=YES													
<b>Acquisition</b>	#	Target											
	1	NONE											
<b>Template</b>	AcqFilter	Primary Channel			Simultaneous Imaging			Imager Subarray					
		ALL			YES			FULL					
<b>Dithers</b>	#	Dither Type			Optimized For			Direction					
	1	4-Point			EXTENDED SOURCE			NEGATIVE					
<b>Spectral Elements</b>	#	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	F1130W	FASTR1	94	1	1	Dither 1	4	4	1043.415	
	1	SHORT(A)	MRSLONG		SLOWR1	11	1	1	Dither 1	4	4	1051.156	
	1	SHORT(A)	MRSSHORT		SLOWR1	11	1	1	Dither 1	4	4	1051.156	
	2		IMAGER	F1130W	FASTR1	94	1	1	Dither 1	4	4	1043.415	
	2	MEDIUM(B)	MRSLONG		SLOWR1	11	1	1	Dither 1	4	4	1051.156	
	2	MEDIUM(B)	MRSSHORT		SLOWR1	11	1	1	Dither 1	4	4	1051.156	
	3		IMAGER	F1130W	FASTR1	94	1	1	Dither 1	4	4	1043.415	
	3	LONG(C)	MRSLONG		SLOWR1	11	1	1	Dither 1	4	4	1051.156	
	3	LONG(C)	MRSSHORT		SLOWR1	11	1	1	Dither 1	4	4	1051.156	

Special Requirements

Sequence Observations 5, 6, Non-interruptible

Proposal 2368 - Observation 7 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

Fri Apr 28 21:00:59 GMT 2023

<b>Observation</b>	<b>Proposal 2368, Observation 7: J2118 Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy Background Observations:[J2118 Back Obs (Obs 8)] Comments: Source has large outflow so need off-scene nod (added background exposure for this)																																																																																																																																													
	(Visit 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																																																																																																																													
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Special Requirements

Sequence Observations 7, 8, Non-interruptible



Proposal 2368 - Observation 8 - What Lies Beneath: Understanding the Hidden Engines Driving Extreme Outflows and Galaxy Quenc...

Fri Apr 28 21:00:59 GMT 2023

<b>Observation</b>	<b>Proposal 2368, Observation 8: J2118 Back Obs</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy Background Observation For: [J2118 Obs (Obs 7)]												
	(Visit 8:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
<b>Fixed Targets</b>	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous				
	(6)	J2118-BACKGROUND	RA: 21 18 24.0624 (319.6002600d) Dec: +00 16 29.43 (.27484d) Equinox: J2000			Epoch of Position: 2000							
Comments: Using background for off-scene nod Category=Unidentified Description=[Blank field] Extended=NO													
<b>Acquisition</b>	#	Target											
	1	NONE											
<b>Template</b>	AcqFilter	Primary Channel			Simultaneous Imaging			Imager Subarray					
		ALL			YES			FULL					
<b>Dithers</b>	#	Dither Type			Optimized For			Direction					
	1	4-Point			EXTENDED SOURCE			NEGATIVE					
<b>Spectral Elements</b>	#	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
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	2		IMAGER	F1130W	FASTR1	77	2	1	Dither 1	4	8	1720.525	
	2	MEDIUM(B)	MRSLONG		SLOWR1	18	1	1	Dither 1	4	4	1720.074	
	2	MEDIUM(B)	MRSSHORT		SLOWR1	18	1	1	Dither 1	4	4	1720.074	
	3		IMAGER	F1130W	FASTR1	77	2	1	Dither 1	4	8	1720.525	
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