



# 4586 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at $z > 11$ to Understand the Origin of the Overabundance of Early Luminous Galaxies

Cycle: 3, Proposal Category: GO

## INVESTIGATORS

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Mr. Yi Xu (CoI)	University of Tokyo, Institute of Cosmic Ray Research
Dr. Yechi Zhang (CoI) (US Admin CoI)	California Institute of Technology

## OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	Ha	MIRI Medium Resolution Spectroscopy	(1) CEERS2_588
	6	Ha_2	MIRI Medium Resolution Spectroscopy	(1) CEERS2_588
	2	OIII	MIRI Medium Resolution Spectroscopy	(1) CEERS2_588
	3	Imaging	MIRI Imaging	(1) CEERS2_588
	4	Background_Ha	MIRI Medium Resolution Spectroscopy	(1) CEERS2_588
	5	Background_OIII	MIRI Medium Resolution Spectroscopy	(1) CEERS2_588

## **ABSTRACT**

The JWST is currently unveiling a significant number of bright galaxies at  $z > 11$ , both through photometry and spectroscopy. The remarkably high number density of these luminous galaxies, compared to theoretical model predictions, raises questions about potential differences in the physical properties of galaxies at such extreme redshifts and those at lower redshift. However, the exact physical mechanism responsible for this overabundance is still a subject of debate, primarily because the currently available NIRSpec dataset does not cover the rest-optical lines such as H $\alpha$  and [OIII] at  $z > 11$ , which are essential for investigating key physical properties. Given that GN-z11 at  $z = 10.60$  (being observed in Cycle 2) exhibits atypical features, studying another bright galaxy at  $z \sim 11$  with MIRI is crucial for understanding the physical origins responsible for the overabundance.

In this proposal, we aim to conduct MIRI MRS spectroscopy and imaging of CEERS2-588, the most luminous galaxy spectroscopically confirmed at  $z > 11$ . These observations will yield detections of strong rest-optical lines and allow us to investigate critical physical properties such as stellar mass, star formation rate, metallicity, AGN activity, and burstiness, which are of intense interest in the context of the overabundance of  $z > 11$  galaxies. The successful detection will open the door to ambitious follow-up observations targeting more  $z > 11$  galaxies to obtain a comprehensive understanding of properties of early galaxies. Conversely, the absence of these emission lines would pose an immediate question about the nature of this galaxy, which appears UV-luminous despite indications of extremely weak emission lines.

## **OBSERVING DESCRIPTION**

This program will perform MIRI MRS spectroscopy and F560W imaging of CEERS2-588, the brightest galaxy spectroscopically confirmed at  $z > 11$ . We aim to detect rest-frame optical strong emission lines, H $\alpha$  and [OIII]5007, as well as the stellar continuum. We will use the Medium (B) and Short (A) gratings in Channels 1 and 2, respectively, which cover wavelengths of  $\sim 6$   $\mu\text{m}$  and  $\sim 8$   $\mu\text{m}$ , where the [OIII]5007 and H $\alpha$  lines are redshifted. In the MediumB grating, we can also target [OIII]4959 and H $\beta$ . We aim to detect the [OIII]5007 and H $\alpha$  lines at 10 sigma levels.

Proposal 4586 - Targets - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at  $z>11$  to Understand the Origin of...

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	CEERS2_588	RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000	Proper Motion RA: 0 Proper Motion Dec: 0	
<i>Comments:</i> <i>Category=Galaxy</i> <i>Description=[High-redshift galaxies]</i>				
(2)	CEERS2_5429	RA: 14 19 46.3600 (214.9431667d) Dec: +52 56 32.80 (52.94244d) Equinox: J2000		
<i>Comments:</i> <i>Category=Galaxy</i> <i>Description=[High-redshift galaxies]</i>				
(3)	Offset_star	RA: 14 19 40.7530 (214.9198042d) Dec: +52 57 7.32 (52.95203d) Equinox: J2000		
<i>Comments:</i> <i>Category=Unidentified</i> <i>Description=[Visible sources]</i> <i>Extended=NO</i>				

Fixed Targets

Proposal 4586 - Observation 1 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at z>11 to Understand the O...

Mon Feb 03 17:00:17 GMT 2025

<b>Observation</b>	<b>Proposal 4586, Observation 1: Ha</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 1:1) Warning (Form): Data Excess over lower threshold (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>				
	(1)	CEERS2_588	RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000			Proper Motion RA: 0 Proper Motion Dec: 0							
<i>Comments:</i> Category=Galaxy Description=[High-redshift galaxies]													
<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	3 Offset_star	F560W	FAST	4	1	1	11.1	212731				
<b>Template</b>	<b>Primary Channel</b>		<b>Simultaneous Imaging</b>			<b>Imager Subarray</b>			<b>Grating Wheel Direction</b>				
	All MRS		YES			FULL			Allow Auto Reorder				
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>			<b>Optimized For</b>			<b>Direction</b>					
	1	4-Point			POINT SOURCE			NEGATIVE					
	2	4-Point			POINT SOURCE			POSITIVE					
<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	F1000W	FASTR1	102	28	1	Dither 1	4	112	32001.761	
	1	SHORT(A)	MRSLONG		SLOWR1	23	14	1	Dither 1	4	56	32012.493	
	1	SHORT(A)	MRSSHORT		SLOWR1	23	14	1	Dither 1	4	56	32012.493	

Special Requirements

Aperture PA Range 290.0 to 320.0 Degrees (V3 290.0 to 320.0)

Proposal 4586 - Observation 6 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at z>11 to Understand the O...

Mon Feb 03 17:00:17 GMT 2025

<b>Observation</b>	Proposal 4586, Observation 6: Ha_2 Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
	(Visit 6:1) Warning (Form): Data Excess over lower threshold (Visit 6:1) 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>				
	(1)	CEERS2_588	RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000			Proper Motion RA: 0 Proper Motion Dec: 0							
Comments: Category=Galaxy Description=[High-redshift galaxies]													
<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	3 Offset_star	F560W	FAST	4	1	1	11.1	212731				
<b>Template</b>	<b>Primary Channel</b>		<b>Simultaneous Imaging</b>			<b>Imager Subarray</b>			<b>Grating Wheel Direction</b>				
	All MRS		YES			FULL			Allow Auto Reorder				
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>			<b>Optimized For</b>			<b>Direction</b>					
	1	4-Point			POINT SOURCE			NEGATIVE					
	2	4-Point			POINT SOURCE			POSITIVE					
<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	F1000W	FASTR1	102	28	1	Dither 1	4	112	32001.761	
	1	SHORT(A)	MRSLONG		SLOWR1	23	14	1	Dither 1	4	56	32012.493	
	1	SHORT(A)	MRSSHORT		SLOWR1	23	14	1	Dither 1	4	56	32012.493	

Proposal 4586 - Observation 6 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at  $z > 11$  to Understand the O...

Special Requirements

Aperture PA Range 290.0 to 320.0 Degrees (V3 290.0 to 320.0)

Sequence Observations 4, 6, Non-interruptible

Proposal 4586 - Observation 2 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at z>11 to Understand the O...

Mon Feb 03 17:00:17 GMT 2025

<b>Observation</b>	<b>Proposal 4586, Observation 2: OIII</b> <b>Diagnostic Status: Warning</b> Observing Template: MIRI Medium Resolution Spectroscopy																																																															
	(Visit 2:1) Warning (Form): Data Excess over lower threshold (Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																																															
<b>Diagnosics</b>																																																																
<b>Fixed Targets</b>	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>CEERS2_588</td> <td>RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000</td> <td>Proper Motion RA: 0 Proper Motion Dec: 0</td> <td></td> </tr> </tbody> </table>	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous	(1)	CEERS2_588	RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000	Proper Motion RA: 0 Proper Motion Dec: 0		<i>Comments:</i> Category=Galaxy Description=[High-redshift galaxies]																																																				
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	#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID																																																			
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1	MEDIUM(B)	MRSSHORT		SLOWR1	23	15	1	Dither 1	4	60	34305.925																																																					

Proposal 4586 - Observation 2 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at  $z > 11$  to Understand the O...

Special Requirements

Aperture PA Range 290.0 to 320.0 Degrees (V3 290.0 to 320.0)

Sequence Observations 2, 5, Non-interruptible

Proposal 4586 - Observation 3 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at z>11 to Understand the O...

Mon Feb 03 17:00:17 GMT 2025

<b>Observation</b>	<p><b>Proposal 4586, Observation 3: Imaging</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: MIRI Imaging</p>										
<b>Diagnostics</b>	(Visit 3:1) 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>		
	(1)	CEERS2_588	RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000			Proper Motion RA: 0 Proper Motion Dec: 0					
	<p><i>Comments:</i>  <i>Category=Galaxy</i>  <i>Description=[High-redshift galaxies]</i></p>										
<b>Template</b>	<p><b>Subarray</b></p> <p>FULL</p>										
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>	<b>Starting Point</b>	<b>Number of Points</b>	<b>Points</b>	<b>Starting Set</b>	<b>Number of Sets</b>	<b>Optimized For</b>	<b>Direction</b>	<b>Pattern Size</b>	
	1	CYCLING	1	12						LARGE	
<b>Spectral Elements</b>	<b>#</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	F770W	FASTR1	100	3	1	Dither 1	12	36	10056.745	
<b>Special Requirements</b>	<p>Aperture PA Range 244.83544897 to 264.83544897 Degrees (V3 240.0 to 260.0)                  Offset -20.0 arcsec, 35.0 arcsec                  Background Limited. Background no more than 40th percentile above minimum</p>										

Proposal 4586 - Observation 4 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at z>11 to Understand the O...

Mon Feb 03 17:00:17 GMT 2025

<b>Observation</b>	Proposal 4586, Observation 4: Background_Ha Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
<b>Diagnostics</b>	(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
<b>Fixed Targets</b>	#	Name	Target Coordinates				Targ. Coord. Corrections			Miscellaneous			
	(1)	CEERS2_588	RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000				Proper Motion RA: 0 Proper Motion Dec: 0						
	<i>Comments:</i> Category=Galaxy Description=[High-redshift galaxies]												
<b>Acquisition</b>	#	Target											
	1	NONE											
<b>Template</b>	AcqFilter	Primary Channel			Simultaneous Imaging		Imager Subarray		Grating Wheel Direction				
		Imager			YES		FULL		Allow Auto Reorder				
<b>Dithers</b>	#	Dither Type				Optimized For			Direction				
	1	4-Point				BACKGROUND			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
			IMAGER	F560W	SLOWR1	11	4	1	Dither 1	4	16	4491.305	
		SHORT(A)	MRSLONG		SLOWR1	23	2	1	Dither 1	4	8	4491.305	
		SHORT(A)	MRSSHORT		SLOWR1	23	2	1	Dither 1	4	8	4491.305	

Proposal 4586 - Observation 4 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at  $z > 11$  to Understand the O...

Special Requirements

Aperture PA Range 294.83544897 to 324.83544897 Degrees (V3 290.0 to 320.0)

Sequence Observations 4, 6, Non-interruptible

Proposal 4586 - Observation 5 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at z>11 to Understand the O...

Mon Feb 03 17:00:17 GMT 2025

<b>Observation</b>	Proposal 4586, Observation 5: Background_OIII Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy												
<b>Diagnostics</b>	(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
<b>Fixed Targets</b>	#	Name	Target Coordinates				Targ. Coord. Corrections			Miscellaneous			
	(1)	CEERS2_588	RA: 14 19 37.5900 (214.9066250d) Dec: +52 56 43.80 (52.94550d) Equinox: J2000				Proper Motion RA: 0 Proper Motion Dec: 0						
	<i>Comments:</i> Category=Galaxy Description=[High-redshift galaxies]												
<b>Acquisition</b>	#	Target											
	1	NONE											
<b>Template</b>	AcqFilter	Primary Channel			Simultaneous Imaging		Imager Subarray		Grating Wheel Direction				
		Imager			YES		FULL		Allow Auto Reorder				
<b>Dithers</b>	#	Dither Type				Optimized For			Direction				
	1	4-Point				BACKGROUND			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	F560W	SLOWR1	11	4	1	Dither 1	4	16	4491.305	
	1	MEDIUM(B)	MRSLONG		SLOWR1	23	2	1	Dither 1	4	8	4491.305	
	1	MEDIUM(B)	MRSSHORT		SLOWR1	23	2	1	Dither 1	4	8	4491.305	

Proposal 4586 - Observation 5 - MIRI Spectroscopy of the Brightest Galaxy Spectroscopically-Confirmed at  $z > 11$  to Understand the O...

Special Requirements

Aperture PA Range 294.83544897 to 324.83544897 Degrees (V3 290.0 to 320.0)

Sequence Observations 2, 5, Non-interruptible