



4212 - Unveiling the Most Distant Lensed Arc at $z \sim 10$

Cycle: 2, Proposal Category: GO

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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	NIRCam	NIRCam Imaging	(1) SPT0615-57
	2	NIRSpec	NIRSpec MultiObject Spectroscopy	(4) SPT0615_full_MSA14

ABSTRACT

JWST was designed to study distant galaxies in the early universe. It has already discovered many, but most are too faint and small to be studied in detail. To understand early galaxies, we must understand the small star clusters ($r < 100$ pc) within. Gravitational lensing has delivered a few precious highly-magnified galaxies out to $z = 6$ that reveal small star clusters in the early universe with Hubble and now JWST.

Here we propose the first detailed study of a galaxy at $z = 10$, observed just 500 Myr after the Big Bang, well before reionization was complete. SPT0615-JD is the brightest $z \sim 10$ galaxy known, magnified to AB mag 25 and stretched to an arc 2.5" long, revealing structures as small as $r \sim 25$ pc in Hubble imaging.

We propose JWST NIRCam imaging to measure the colors of these star clusters for the first time, yielding age and mass estimates, while resolving still smaller star clusters with radii < 10 pc.

We also propose NIRSpec G395H high-resolution $R \sim 3000$ spectroscopy in spatially resolved segments of the galaxy with MSA slitlets covering the length of the arc. For the first time, we will resolve the [OII] doublet in a galaxy during reionization, yielding its gas density in multiple locations. We will resolve and measure line widths, revealing outflows that may have enabled early galaxies to reionize the universe. We expect to detect [OIII] 4363\AA enabling a direct metallicity measurement when combined with [OIII] 5007\AA that may also be detected in this proposal cycle depending on the redshift we measure.

These data will also deliver ancillary science on many more high-redshift galaxies magnified by the exceptional lensing cluster SPT0615-57.

OBSERVING DESCRIPTION

This proposal will obtain NIRCcam and NIRSpec observations of a candidate $z\sim 10$ galaxy, SPT0615-JD, strongly lensed into a bright arc. We acquire NIRCcam imaging in 8 filters (F090W, F115W, F150W, F200W, F277W, F356W, F410M, and F444W) using the MEDIUM8 readout pattern with 7 groups and 1 integration. We use the INTRAMODULEBOX dither pattern with 4 dithers to fill the gaps in the short wavelength detectors and to maximize the deep area with full exposure time. The exposure time is 2920.4 seconds (0.8 hours) per filter, giving a total of 3.2 hours. NIRCcam roll angles are restricted (within the current planning window Sept 5 – Oct 20) to ensure that the primary target is not impacted by diffraction spikes from 3 nearby relatively bright stars. The NIRCcam imaging data will be obtained at least 60 days prior to the NIRSpec data. Using this strategy we can place slits on any candidate $z\sim 10$ counterimage and new high-redshift galaxy candidates. The NIRCcam imaging will also serve as pre-imaging for the NIRSpec observations.

We obtain NIRSpec MOS high-resolution spectroscopy (G395H) of SPT0615-JD to cover wavelengths between 2.9-5.3 microns. We use a standard 3-shutter slit with 3 nods and two MSA configurations to mitigate artifacts (e.g., snowballs) and provide dithering. For the SPT0615-JD galaxy, we use at least 5 shutters to cover to 2.5 arcsec long arc, plus additional nearby shutters to be used for background estimation. We use the NRSIRS2 readout pattern with 10 groups and 2 integrations. We require the NIRSpec MSA prism data to be obtained at an APA between 134° – 136° . This narrow range is required to place the multi-shutter MSA slitlet along the $z\sim 10$ arc (2.5 arcsec long). An APA of 314° – 316° (a 180° flip) is not available for this target.

The first MSA configuration obtains complete spectra of SPT0615-JD (except for the detector gap), crucially preserving the red end of the spectrum.

The second MSA configuration covers the cluster core for more ancillary targets, while preserving the SPT0615-JD spectrum out to $4.926\mu\text{m}$, or rest-frame 4399\AA assuming $z = 10.2$, for full exposure time on faint lines including H 4340 and [OIII] 4363.

Relaxed or unconstrained source centering constraints allowed for more ancillary targets, most of which are extended (so precise centering is not critical). Ancillary targets were added automatically and then manually by editing the configurations.

Proposal 4212 - Targets - Unveiling the Most Distant Lensed Arc at z~10

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SPT0615-57	RA: 06 15 52.1604 (93.9673350d) Dec: -57 46 50.50 (-57.78069d) Equinox: J2000		
<i>Comments:</i> Category=Clusters of Galaxies Description=[High-redshift clusters, Rich clusters]				
(2)	SPT0615-HIGHZ	RA: 06 15 53.6510 (93.9735458d) Dec: -57 46 39.57 (-57.77766d) Equinox: J2000		
<i>Comments:</i> Description=[]				
(3)	SPT0615-JD_2661	RA: 06 15 55.1150 (93.9796458d) Dec: -57 46 20.51 (-57.77236d) Equinox: J2000		
<i>Comments:</i> Description=[]				
(4)	SPT0615_full_MSA14	RA: 06 15 51.5894 (93.9649558d) Dec: -57 46 0.17 (-57.76671d) Equinox: J2000		
<i>Comments:</i> Description=[]				

Fixed Targets

Proposal 4212 - Observation 1 - Unveiling the Most Distant Lensed Arc at z~10

Tue Oct 24 15:00:42 GMT 2023

Observation	<p>Proposal 4212, Observation 1: NIRCam</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRCam Imaging</p>									
Diagnostics	(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)	SPT0615-57	RA: 06 15 52.1604 (93.9673350d) Dec: -57 46 50.50 (-57.78069d) Equinox: J2000							
	<p><i>Comments:</i> <i>Category=Clusters of Galaxies</i> <i>Description=[High-redshift clusters, Rich clusters]</i></p>									
Template	Module		Subarray			Target Placement				
	ALL		FULL			Module Gap				
Dithers	#	Primary Dither Type		Primary Dithers	Subpixel Dither Type		Dither Size	Subpixel Positions		
	1	INTRAMODULEBOX		4	STANDARD			1		
Spectral Elements	#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
	1	F090W	F410M	MEDIUM8	7	1	4	4	2920.401	
	2	F115W	F277W	MEDIUM8	7	1	4	4	2920.401	
	3	F150W	F356W	MEDIUM8	7	1	4	4	2920.401	
	4	F200W	F444W	MEDIUM8	7	1	4	4	2920.401	
Special Requirements	<p>Aperture PA Range 254 to 256 Degrees (V3 254.0713531 to 256.0713531) Aperture PA Range 264 to 276 Degrees (V3 264.0713531 to 276.0713531) Aperture PA Range 284 to 286 Degrees (V3 284.0713531 to 286.0713531) Aperture PA Range 294 to 302 Degrees (V3 294.0713531 to 302.0713531) Offset 86.5 arcsec, 1.5 arcsec</p> <p>2 After 1 by 60.0 Days to <None specified></p>									

Proposal 4212 - Observation 2 - Unveiling the Most Distant Lensed Arc at z~10

Tue Oct 24 15:00:42 GMT 2023

Observation	Proposal 4212, Observation 2: NIRSpec Diagnostic Status: Warning Observing Template: NIRSpec MultiObject Spectroscopy										
	(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.										
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous		
	(4)	SPT0615_full_MSA14	RA: 06 15 51.5894 (93.9649558d) Dec: -57 46 0.17 (-57.76671d) Equinox: J2000								
<i>Comments: Description=[]</i>											
Acquisition	#	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	Filter: CLEAR; Readout: NRSRAPIDD1; 8 sources in 2 quads; [Optimal TA Accuracy]	SAME	CLEAR	Auto Acq MSA Config	NRSRAPIDD1	3	1	4	257.682	
Template	TA Method	Obtain Confirmation Images		Science Aperture	Primary Candidate List	Filler Candidate List	Spectral Overlap Map	Spectral Overlap Threshold			
	MSATA	No		MSA Center	Primary (7 sources)	Filler (275 sources)	jwst-nirspec-g395h	1.5			
Reference Stars	Visit	ID	RA	Dec	Magnitude	Visit	ID	RA	Dec	Magnitude	
	1	3126	93.979223	-57.766721	22.724	1	4588	93.922439	-57.740503	22.260	
	1	3150	93.992967	-57.766007	23.964	1	5914	93.937108	-57.733707	22.679	
	1	3431	93.990353	-57.759671	22.648	1	5920	93.933333	-57.733590	23.900	
	1	3578	93.947883	-57.751954	22.720	1	6712	93.938900	-57.731127	22.744	
Spectral Elements	#	Exposure Specification	MSA Configuration	Nod Pattern	Pointing	Aperture PA	Dispersion Offset (Shutters)	Cross-Dispersion Offset (Shutters)	Total Dithers	Total Integrations	Total Exposure Time
	1	1 (G395H/F290LP)	full14b- manual_4212.p80 c1e1n1	3 Shutter Slitlet	93.989902083333 33 Degrees - 57.74239222222 236 Degrees	134.97893512221 947			3	6	4464.2
	2	1 (G395H/F290LP)	core1s- manual2_EXPOR T_4212.p79c1e1n 1	3 Shutter Slitlet	93.972143708333 33 Degrees - 57.75216777777 8 Degrees	134.99393094668 85			3	6	4464.2

Proposal 4212 - Observation 2 - Unveiling the Most Distant Lensed Arc at z~10

Special Requirements

Aperture PA Range 134 to 136 Degrees (V3 355.4254303 to 357.4254303)
MSA Scheduled Aperture PA 135.0000 to 135.0000 Degrees (V3 356.42545 to 356.42545)
2 After 1 by 60.0 Days to <None specified>