



# 11451 - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

Cycle: 5, Proposal Category: GO

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Aliza G. Beverage (PI)</b>	<b>Carnegie Institution of Washington</b>
Dr. Andrew B. Newman (CoI)	Carnegie Institution of Washington
Dr. Joel Leja (CoI)	The Pennsylvania State University
Chloe M. Cheng (CoI) (ESA Member)	Universiteit Leiden
Dr. Zhuyun Zhuang (CoI)	Northwestern University
Prof. Meng Gu (CoI)	University of Hong Kong
Prof. Jenny Emma Greene (CoI)	Princeton University
Prof. Mariska Kriek (CoI) (ESA Member)	Universiteit Leiden
Martje Slob (CoI) (ESA Member)	Universiteit Leiden
Dr. Massimo Pascale (CoI)	University of California - Los Angeles
Dr. Bingjie Wang (CoI)	Princeton University
Prof. Charlie Conroy (CoI)	Harvard University
Dr. Katherine Suss (CoI)	University of Colorado at Boulder

## OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	zf-uds-7329	NIRSpec MultiObject Spectroscopy	(1) catalog_ZF-UDS-7329
	2	zf-uds-7329	NIRSpec MultiObject Spectroscopy	(1) catalog_ZF-UDS-7329

## **ABSTRACT**

ZF-UDS-7329 is arguably the most extreme massive galaxy known. At  $z = 3.2$ , it appears to have formed all  $10^{11}$  of its stars at  $z=11$  within only 200–500 Myr. Such rapid formation challenges current models of galaxy growth, implying an almost perfect (and thus unrealistic) conversion of gas into stars. However, existing interpretations rely on low-resolution, low-S/N spectra, leaving significant degeneracies between formation history, metallicity, and alpha-enhancement. We propose ultra-deep JWST/NIRSpec (G235M/F170LP) spectroscopy of ZF-UDS-7329 to obtain the first precise chemical abundance pattern of a galaxy at  $z>3$ . This dataset will break formation-history degeneracies, provide critical priors for stellar population models, and test whether ZF-UDS-7329 truly formed “too early.” It will also illuminate how the universe’s first massive galaxies formed. ZF-UDS-7329 is a rare fossil from cosmic dawn—likely a relic of the puzzling ‘Blue Monsters’ at  $z > 8$ , whose extreme UV luminosities and unusual chemistries challenge current models of the early universe. As a remnant of this epoch, ZF-UDS-7329 offers a unique laboratory for probing physical conditions otherwise inaccessible at  $z>8$ . Detailed chemical abundances will directly test competing explanations for these extreme systems. For example, we will set empirical lower limits on their star-formation efficiencies and, for the first time, reveal whether they formed with top-heavy IMFs. As such, ZF-UDS-7329 not only provides a benchmark for testing stellar-population models, but also offers a singular opportunity to empirically test the physics of rapid star formation at cosmic dawn.

## **OBSERVING DESCRIPTION**

We propose to obtain ultra-deep, rest-frame optical, medium-resolution continuum spectroscopy of ZF-UDS-7329, a maximally old quiescent galaxy at  $z = 3.2$ , using NIRSpec MSA (G235M/F170LP). The MSA configuration will include several massive quiescent and star-forming filler galaxies at  $z = 3–3.5$ , as well as the brightest known LRD at  $z = 3.1$ . ZF-UDS-7329 lies within the PRIMER–UDS field, with extensive JWST/NIRCam and HST imaging already available; thus, no pre-imaging is required. We do not have any PA restraints.

ZF-UDS-7329 will be placed on the left side of the MSA to ensure that the chip gap does not fall on any critical rest-frame optical spectral features. We will give it a five-shutter slit, while the filler galaxies will be assigned three-shutter slits, extended to four or five shutters when available. We will use a custom 2-position nodding pattern to allow for better background subtraction. We will also apply a fixed dither of 1 shutter in either dispersion direction, to minimize impacts of detector defects.

We will observe this pointing/configuration for 34 hrs, divided over two visits. Each visit consists of 40 or 44 integrations of 1473.478 seconds each, with 20 groups per integration. We need exactly the same PA for each visit, so we can use the same mask design. We will use the NRSIRS2 read-out mode.

Proposal 11451 - Targets - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	catalog_ZF-UDS-7329	RA: 02 17 7.8723 (34.2828012d)		
			Dec: -05 14 18.77 (-5.23855d)		
			Equinox: J2000		
		<i>Comments:</i>			
		<i>Description=[]</i>			

Proposal 11451 - Observation 1 - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

Fri Mar 13 21:06:42 GMT 2026

<b>Observation</b>	<p>Proposal 11451, Observation 1: zf-uds-7329</p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRSpec MultiObject Spectroscopy</p>										
<b>Diagnostics</b>	(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)	catalog_ZF-UDS-7329	RA: 02 17 7.8723 (34.2828012d) Dec: -05 14 18.77 (-5.23855d) Equinox: J2000								
	<i>Comments: Description=[]</i>										
<b>Acquisition</b>	<b>#</b>	<b>Reference Star Bin</b>	<b>Target</b>	<b>Filter</b>	<b>MSA Configuration</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>Optional ETC ID</b>
	1		SAME	F140X	Auto Acq MSA Config	NRSRAPID	3	1	4	171.788	
<b>Template</b>	<b>TA Method</b>	<b>HFF Readout Mode</b>	<b>Obtain Confirmation Images</b>	<b>Science Aperture</b>	<b>Primary Candidate List</b>	<b>Filler Candidate List</b>	<b>Spectral Overlap Map</b>	<b>Spectral Overlap Threshold</b>			
	MSATA	false	No	MSA Center	New Candidate Set (1022 sources)	New Candidate Set (1022 sources)	mwst-nirspec-g235m	1.5			
<b>Reference Stars</b>											

Proposal 11451 - Observation 1 - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

#	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 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
2	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
3	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
4	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
5	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
6	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
7	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
8	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
9	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
10	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
11	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
12	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
13	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
14	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956

Proposal 11451 - Observation 1 - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

#	Exposure Specification	MSA Configuration	Nod Pattern	Pointing	Aperture PA	Dispersion Offset (Shutters)	Cross-Dispersion Offset (Shutters)	Total Dithers	Total Integrations	Total Exposure Time
15	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
16	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
17	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
18	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
19	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
20	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
<b>Special Requirements</b>	MSA Planned Aperture PA 203.0000 to 203.0000 Degrees (V3 64.4254303 to 64.4254303)									

Proposal 11451 - Observation 2 - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

Fri Mar 13 21:06:42 GMT 2026

<b>Observation</b>	<p>Proposal 11451, Observation 2: zf-uds-7329</p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRSpec MultiObject Spectroscopy</p>										
<b>Diagnostics</b>	<p>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>										
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>		<b>Targ. Coord. Corrections</b>			<b>Miscellaneous</b>			
	(1)	catalog_ZF-UDS-7329	RA: 02 17 7.8723 (34.2828012d) Dec: -05 14 18.77 (-5.23855d) Equinox: J2000								
	<p><i>Comments:</i> Description=[]</p>										
<b>Acquisition</b>	<b>#</b>	<b>Reference Star Bin</b>	<b>Target</b>	<b>Filter</b>	<b>MSA Configuration</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>Optional ETC ID</b>
	1		SAME	F140X	Auto Acq MSA Config	NRSRAPID	3	1	4	171.788	
<b>Template</b>	<b>TA Method</b>	<b>HFF Readout Mode</b>	<b>Obtain Confirmation Images</b>	<b>Science Aperture</b>	<b>Primary Candidate List</b>	<b>Filler Candidate List</b>	<b>Spectral Overlap Map</b>	<b>Spectral Overlap Threshold</b>			
	MSATA	false	No	MSA Center	New Candidate Set (1022 sources)	New Candidate Set (1022 sources)	mwst-nirspec-g235m	1.5			
<b>Reference Stars</b>											

Proposal 11451 - Observation 2 - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

#	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 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
2	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
3	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
4	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
5	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
6	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
7	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
8	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
9	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00090862524 868	1.0		1	2	2946.956
10	1 (G235M/F170LP)	c1		34.272955125 Degrees - 5.2515955555555 82 Degrees	203.00092096440 414	-1.0		1	2	2946.956
11	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
12	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
13	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
14	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956

Proposal 11451 - Observation 2 - How fast is too furious? Ultradeep spectroscopy of a fossil from cosmic dawn

#	Exposure Specification	MSA Configuration	Nod Pattern	Pointing	Aperture PA	Dispersion Offset (Shutters)	Cross-Dispersion Offset (Shutters)	Total Dithers	Total Integrations	Total Exposure Time
15	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
16	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
17	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
18	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
19	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
20	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
21	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00089629948 03	1.0		1	2	2946.956
22	1 (G235M/F170LP)	c2		34.273092458333 33 Degrees - 5.2516536111111 24 Degrees	203.00090863877 668	-1.0		1	2	2946.956
Special Requirements	MSA Planned Aperture PA 203.0000 to 203.0000 Degrees (V3 64.4254303 to 64.4254303)									