



# 2279 - Where Cosmic Dawn Breaks First: Mapping the Primordial Overdensity Powering a $z \sim 9$ Ionized Bubble

Cycle: 1, Proposal Category: GO

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Rohan Naidu (PI)</b>	<b>Massachusetts Institute of Technology</b>
Prof. Pascal Oesch (CoI) (ESA Member) (Contact)	University of Geneva, Department of Astronomy
Prof. Charlie Conroy (CoI) (US Admin CoI)	Harvard University
Ecaterina Leonova (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Dr. Sandro Tacchella (CoI) (ESA Member)	University of Cambridge
Dr. Anne Hutter (CoI) (ESA Member)	Cosmic Dawn Center, Niels Bohr Institute
Prof. J. Stuart B. Wyithe (CoI)	University of Melbourne
Simon Mutch (CoI)	University of Melbourne
Yuxiang Qin (CoI) (ESA Member)	Scuola Normale Superiore, Pisa
Prof. Adi Zitrin (CoI)	Ben Gurion University of the Negev
Prof. Richard S. Ellis (CoI) (ESA Member)	University College London
Dr. Guido Roberts-Borsani (CoI)	University of California - Los Angeles
Prof. Daniel P. Stark (CoI)	University of Arizona
Dr. Ryan Endsley (CoI)	The University of Texas at Austin
Prof. Garth D. Illingworth (CoI)	University of California - Santa Cruz
Mr. Daniel K. Magee (CoI)	University of California - Santa Cruz
Dr. Rychard Bouwens (CoI) (ESA Member)	Universiteit Leiden
Prof. Ivo Labbe (CoI)	Swinburne University of Technology
Dr. Renske Smit (CoI) (ESA Member)	Liverpool John Moores University
Dr. Mauro Stefanon (CoI) (ESA Member)	Universitat de Valencia, Observatori Astronomic
Dr. Josephine Kerutt (CoI) (ESA Member)	University of Geneva, Department of Astronomy

**OBSERVATIONS**

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
F444W-Grism				
	1	NIRCam Grism	NIRCam Wide Field Slitless Spectroscopy	(1) EGSZ8P7-BUBBLE

**ABSTRACT**

Models of cosmic reionization predict that the earliest star-forming systems develop in primordial overdensities which, in turn, create ionized bubbles. With time, these bubbles grow and coalesce until the intergalactic medium is fully ionized. Since Lyman-alpha photons originating in these protoclusters can propagate freely through ionized gas, the highest redshift Lyman Alpha emitters (LAEs) act as valuable tracers of early ionized bubbles. We present evidence that the highest redshift LAE, EGSz8p7 ( $z=8.68$ ), is likely embedded in such an overdensity. Collectively, in all of HST's deep fields, blank fields and gravitationally-lensed fields spanning  $>1000 \text{ arcmin}^2$  there are  $\sim 30$  photometric candidates at  $z\sim 9$ , yet a third lie within  $3.75'$  ( $10 \text{ cMpc}$ ) of EGSz8p7. To confirm and exploit this extraordinary early overdensity we seek systemic redshifts and diagnostic features only JWST can provide. We propose blind, grism spectroscopy to map the ionized bubble around EGSz8p7 using the [OIII] doublet. A blind survey is optimal for determining a complete census of EGSz8p7's physical neighbors. Spitzer/IRAC color excesses at  $z>8$  imply extreme [OIII] EWs ( $\sim 6000 \text{ \AA}$ ) ensuring efficient use of JWST. Stellar population modeling of the sources around EGSz8p7 may give us the strongest constraints yet on when star-formation first commenced after the Big Bang (i.e., cosmic dawn). Our spectra will likewise constrain the ionizing photon production efficiency, a key unknown in reionization calculations. Our observing strategy is designed for maximum legacy value with a footprint overlapping the CEERS ERS survey and use of the wide F444W grism that will guarantee additional  $1<z<9$  science.

**OBSERVING DESCRIPTION**

Our goal is to reach a 6-sigma emission-line sensitivity for NIRCam/grism observations of  $3.3 \times 10^{-18} \text{ erg/s/cm}^2$ , which is the expected, average [OIII]5007 flux of the faintest neighboring sources around EGSz8p7 identified in HST imaging (with  $H=27.5 \text{ mag}$ ). Based on the ETC, we can reach such lines in  $8 \times 880 \text{ s}$  (MEDIUM2,  $N_{\text{groups}}=9$ ,  $N_{\text{int}}=1$ ) in the F444W filter. We will obtain two pointings, offset by 1150 pixels in order to reach full coverage of the [OIII]5007 line at  $z=8.68$  (at  $4.85 \text{ micron}$ ) over two areas of  $2.2 \times 2.6 \text{ arcmin}^2$ . The orient requirement is set to cover the spectroscopically confirmed source EGSz8p7 in one detector and the very luminous  $z\sim 9$  galaxy candidate EGS910-3 in the other. Background-limited exposures are required, as the achieved S/N of our emission line spectra changes by  $>10\%$  at  $\sim 4 \text{ micron}$  between low and high background. These constraints have only limited impact on the scheduling, which is still possible over 51 days.

We will only use one dispersion direction, GrismR, given that the GrismC results in disproportional overheads (due to the very large offsets required

## JWST Proposal 2279 (Created: Wednesday, March 29, 2023 at 3:00:31 PM Eastern Standard Time) - Overview

for the out-of field images). Additionally, creating the required area with full wavelength coverage would result in further extra costs. We will build on the community's expertise with the WFC3/IR grisms and public toolsets to fully model the contamination of all galaxies within the field of view. We will obtain our exposures with 4-point large scale dithers, but no sub-pixel dithering. Direct images are taken after the last grism exposures. At the same time, we will take short-wavelength imaging over the same field. Images are taken with the SHALLOW4 and MEDIUM2 readout modes (6 and 9 groups) for the direct images and grism exposures, respectively.

The direct and out-of-field image exposure times are set such that we will detect every source in imaging at 5sigma if it shows a 5sigma line in the grism spectrum. This amounts to a 15min exposure only. The total request is therefore 7.1 hours, of which 4.4hrs are science time.

No parallels are requested.

Proposal 2279 - Targets - Where Cosmic Dawn Breaks First: Mapping the Primordial Overdensity Powering a z~9 Ionized Bubble

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)  <i>Comments:</i> <i>Category=Unidentified</i> <i>Description=[Blank field]</i>	EGSZ8P7-BUBBLE	RA: 14 19 52.6273 (214.9692804d) Dec: +52 53 58.60 (52.89961d) Equinox: J2000		

Proposal 2279 - Observation 1 - Where Cosmic Dawn Breaks First: Mapping the Primordial Overdensity Powering a z~9 Ionized Bubble

Wed Mar 29 20:00:32 GMT 2023

<b>Observation</b>	<p><b>Proposal 2279, Observation 1: NIRCam Grism</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRCam Wide Field Slitless Spectroscopy</p>											
<b>Diagnostics</b>	<p>(NIRCam Grism (Obs 1)) Warning (Form): Use of only one of GRISMR or GRISMC may result in spectral overlap from multiple sources that can't be corrected. Users should address this issue in their proposal text.</p> <p>(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(Visit 1:2) 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)	EGSZ8P7-BUBBLE	RA: 14 19 52.6273 (214.9692804d) Dec: +52 53 58.60 (52.89961d) Equinox: J2000									
	<p><i>Comments:</i>  <i>Category=Unidentified</i>  <i>Description=[Blank field]</i></p>											
<b>Template</b>	<b>Module</b>		<b>Subarray</b>				<b>Grism (Long Wavelength)</b>					
	ALL		FULL				GRISMR					
<b>Mosaic</b>	<b>Rows</b>	<b>Columns</b>	<b>Row Overlap %</b>	<b>Column Overlap %</b>	<b>Row shift</b>	<b>Column shift</b>	<b>Tile Order</b>					
	1	2	3.0	76.0	0.0	0.0	DEFAULT					
<b>Dithers</b>	<b>#</b>	<b>Primary Dither Type</b>			<b>Primary Dithers</b>			<b>Subpixel Positions</b>				
	1	INTRAMODULEBOX			4			NONE				
<b>Direct Image</b>	<b>#</b>	<b>Short Filter</b>	<b>Long 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>	<b>Grism (Long Wavelength)</b>	<b>Exposure Type</b>	<b>Total Dithers</b>
	1	F210M	F444W	SHALLOW4	6	1	1	311.366		GRISMR	Direct Image	1
<b>Spectral Elements</b>	<b>#</b>	<b>Short Filter</b>	<b>Long 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>	<b>Grism (Long Wavelength)</b>	<b>Exposure Type</b>	<b>Total Dithers</b>
	1	F182M	F444W	MEDIUM2	9	1	4	3521.661		GRISMR	Grism (Long Wavelength)	4
	2	F210M	F444W	MEDIUM2	9	1	4	3521.661		GRISMR	Grism (Long Wavelength)	4
	3	F210M	F444W	SHALLOW4	6	1	2	622.733			Out of Field	2

Proposal 2279 - Observation 1 - Where Cosmic Dawn Breaks First: Mapping the Primordial Overdensity Powering a z~9 Ionized Bubble

Special Requirements

Group Visits within 53.0 Days  
Aperture PA Range 173 to 216 Degrees (V3 173.0 to 216.0)  
Visits Same PA  
Background Limited. Background no more than 30th percentile above minimum