



# 3516 - All the Little Things: Pop III Signatures & the Ionizing Photon Budget of Dwarf Galaxies in the Epoch of Reionization

Cycle: 2, Proposal Category: GO

## INVESTIGATORS

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Dr. Sandro Tacchella (CoI) (ESA Member)	University of Cambridge
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**OBSERVATIONS**

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
NIRCam LW WFSS and SW imaging				
	1	Roll 1	NIRCam Wide Field Slitless Spectroscopy	(1) ABELL2744
	2	Roll 2	NIRCam Wide Field Slitless Spectroscopy	(1) ABELL2744

**ABSTRACT**

The lowest mass galaxies in the first billion years hold the key to two frontiers of observational cosmology: (i) finding the most metal-poor first generations of stars, including metal-free Pop III stars; (ii) identifying the sources that drove cosmic reionization. The inherent faintness of these galaxies and the need for sensitive rest-optical spectroscopy of large samples have been the main limitations.

Here we propose a NIRCam grism survey at JWST's most sensitive wavelength (3-4 micron), in an optimally designed mosaic, around the powerful lensing cluster Abell 2744. Leveraging the grism's spatial resolution, in some cases amplified by lensing, we will perform a flux-limited survey for metal-poor (perhaps metal-free) pockets of star formation within ~200 faint ( $M_{UV} < -16$ ) galaxies at  $z \sim 5-7$ . If not for Pop III stars themselves, this search promises to reveal Pop II stars that may have been directly enriched by Pop III supernovae, analogs of which have been observed in Milky Way dwarf galaxies. We will, for the first time, directly measure the distribution of ionizing efficiencies among faint galaxies at  $z \sim 7$  using Balmer lines exactly in the luminosity regime where reionization models have major differences.

Along with simultaneous deep F090W imaging on the cluster, our survey is expected to yield ~3000 spectroscopic redshifts from  $z \sim 1-7$ , vastly enhancing the legacy value of the A2744 field. Crucially, we will measure redshifts for multiply imaged sources in ~80% of the A2744 mosaic that is yet to be covered by spectroscopic surveys, including two high magnification regions, thereby constraining the lensing model underpinning all community science in this field.

**OBSERVING DESCRIPTION**

We propose a deep flux-limited grism spectroscopic survey of a ~28 arcmin<sup>2</sup> region around the lensing cluster Abell 2744 with NIRCam/WFSS at 3-4 micron in the F356W filter. This is optimally exploiting JWST's most sensitive wavelength range and largest WFSS field of view and targets the strongest rest-frame optical lines of high-redshift galaxies that are unobservable at these redshifts by any other facility.

The primary aim is to detect H $\beta$ + $[OIII]$  emission lines at  $z \sim 5.3-7$  in order to identify the most metal poor pockets of star formation and measure the ionizing photon production efficiency of these dwarf galaxies at the end of the epoch of reionization. In addition, the observations will obtain deep F090W imaging data on the same area on the sky, complementing existing imaging data that allows a search for faint UV-selected galaxies at  $z \sim 7$  and the better characterisation of the spectral energy distributions of all objects in the field. Our data is expected to identify a large sample of

## JWST Proposal 3516 (Created: Tuesday, August 29, 2023 at 7:00:18 PM Eastern Standard Time) - Overview

spectroscopic redshifts, the vast majority new discoveries and probing a large area that has been untargeted by previous or ongoing spectroscopic follow up. Redshifts for multiply imaged sources will constrain the lensing model underpinning all science in this field.

The observations are split in two groups, Roll 1 and Roll 2. Both target the lensing cluster with a 2x2 mosaic with 72 % column overlap and 5% row overlap. The general PA is constrained to yield good overlap with existing JWST imaging data, but the relative PA between the two groups should be different by 4-8 degrees. The column overlap is designed to yield contiguous coverage from 3.15-3.95 micron, and simultaneously results in a deep central stripe where modules A and B overlap, yielding spectra with orthogonal dispersion directions that will be used to solve the grism confusion problems for single line emitters. The small PA difference results in a large leverage towards the outer regions of the mosaic, where each object will only be covered by a single dispersion direction. The PA differences will help solving the confusion problem in these areas. Cycle 1 JWST NIRCам WFSS results have shown that continuum contamination can be efficiently filtered out thanks to the  $R \sim 1500$  resolution of the data, the high contrast of strong emission-lines from high-redshift galaxies and the flat observed continuum spectrum from the main foreground population at  $z \sim 1-2$ . Continuum spectroscopy on itself is not a science goal of this program, but can be performed for the brightest objects.

Each visit (8 in total) consists of two sequences of WFSS observations in the F356W filter with 3 INTRAMODULEX primary dithers and 4 subpixel dithers using 4-POINT-MEDIUM-WITH-NIRISS to optimise the image quality. MEDIUM8 with 5 groups/integration is used for readout of all WFSS observations. The total WFSS exposure time is 12.4 ks per visit, therefore 24.8 ks for the majority of the sky area after both rolls are observed (a factor two higher for three central stripes that cover the main regions with high magnification). Direct and two out of field images in the F356W filter with exposure times 526s are taken at the end of the WFSS exposure sequences, with SHALLOW4 readouts with 10 groups/integration. Simultaneous extremely deep imaging in the F090W filter is performed with the SW channel during all exposures, which will have a total integration time of 27.8ks for the majority of the sky area.

Coordinated parallels with NIRISS imaging that will overlap with previous NIRISS imaging will be undertaken in the missing F090W and F277W filters. Standard NIS readouts with 11 or 12 Groups/Integration (depending on the primary NIRCам integration) will be used. The total exposure time of the NIRISS parallel imaging in F090W and F277W filters will be 3.5 and 3.8 hours, respectively.

Proposal 3516 - Targets - All the Little Things: Pop III Signatures & the Ionizing Photon Budget of Dwarf Galaxies in the Epoch of Reio...

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	ABELL2744	RA: 00 14 18.2514 (3.5760475d)	Dec: -30 22 46.04 (-30.37946d)	
<i>Comments:</i> Category=Clusters of Galaxies Description=[Abell clusters]					

Proposal 3516 - Observation 1 - All the Little Things: Pop III Signatures & the Ionizing Photon Budget of Dwarf Galaxies in the Epoch ...

Wed Aug 30 00:00:18 GMT 2023

<b>Observation</b>	<b>Proposal 3516, Observation 1: Roll 1</b>												
	<b>Diagnostic Status: Warning</b> Observing Template: NIRCam Wide Field Slitless Spectroscopy Coordinated Parallel Template(s): NIRISS Imaging												
<b>Diagnostics</b>	(Roll 1 (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.												
	(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
	(Visit 1:2) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
	(Visit 1:3) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
	(Visit 1:4) 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)	ABELL2744	RA: 00 14 18.2514 (3.5760475d) Dec: -30 22 46.04 (-30.37946d) Equinox: J2000										
	<i>Comments:</i> Category=Clusters of Galaxies Description=[Abell clusters]												
<b>Template</b>	<b>NIRCam Wide Field Slitless Spectroscopy</b>						<b>NIRISS Imaging</b>						
	Module: ALL Subarray: FULL Grism (Long Wavelength): GRISMR Show partial spectra region in Aladin: false												
<b>Mosaic</b>	<b>Rows</b>	<b>Columns</b>	<b>Row Overlap %</b>			<b>Column Overlap %</b>			<b>Row shift (deg)</b>		<b>Column shift (deg)</b>		<b>Tile Order</b>
	2	2	5.0			72.0			0.0		0.0		DEFAULT
<b>Dithers</b>	<b>#</b>	<b>Primary Dither Type</b>				<b>Primary Dithers</b>			<b>Subpixel Positions</b>				
	1	INTRAMODULEX				3			4-POINT-MEDIUM-WITH-NIRISS				
<b>Direct Image</b>	<b>NIRCam Wide Field Slitless Spectroscopy</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	F090W	F356W	SHALLOW4	10	1	1	526.102		GRISMR	Direct Image	1	
<b>Spectral Elements</b>	<b>NIRCam Wide Field Slitless Spectroscopy</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	F070W	F356W	MEDIUM8	5	1	12	6184.38		GRISMR	Grism (Long Wavelength)	12	
	2	F090W	F356W	MEDIUM8	5	1	12	6184.38		GRISMR	Grism (Long Wavelength)	12	
	3	F090W	F356W	SHALLOW4	10	1	2	1052.203			Out of Field	2	

Proposal 3516 - Observation 1 - All the Little Things: Pop III Signatures & the Ionizing Photon Budget of Dwarf Galaxies in the Epoch ...

Spectral Elements	NIRISS Imaging	Filter	Grism	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID	
	1		F090W		NIS	11	1	12	12	5797.856	
	2		F277W		NIS	11	1	12	12	5797.856	
	3		F090W		NIS	12	1	1	1	526.102	
	4		F277W		NIS	12	1	2	2	1052.203	
Special Requirements	Group Visits within 53.0 Days Aperture PA Range 25 to 65 Degrees (V3 25.0 to 65.0) Visits Same PA No Parallel Attachments V3 PA Offset 1 from 2 by 4 to 8 Degrees (Same offsets in Aperture)										

Proposal 3516 - Observation 2 - All the Little Things: Pop III Signatures & the Ionizing Photon Budget of Dwarf Galaxies in the Epoch ...

Wed Aug 30 00:00:18 GMT 2023

<b>Observation</b>	<b>Proposal 3516, Observation 2: Roll 2</b> <b>Diagnostic Status: Warning</b> Observing Template: NIRCam Wide Field Slitless Spectroscopy Coordinated Parallel Template(s): NIRISS Imaging											
	(Roll 2 (Obs 2)) 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. (Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Visit 2:2) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Visit 2:3) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Visit 2:4) Warning (Form): Overheads are provisional until the Visit Planner has been run.											
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	(1)	ABELL2744	RA: 00 14 18.2514 (3.5760475d) Dec: -30 22 46.04 (-30.37946d) Equinox: J2000  <i>Comments:</i> Category=Clusters of Galaxies Description=[Abell clusters]									
<b>Template</b>	<b>NIRCam Wide Field Slitless Spectroscopy</b>						<b>NIRISS Imaging</b>					
	Module: ALL Subarray: FULL Grism (Long Wavelength): GRISMR Show partial spectra region in Aladin: false											
<b>Mosaic</b>	<b>Rows</b>	<b>Columns</b>	<b>Row Overlap %</b>		<b>Column Overlap %</b>		<b>Row shift (deg)</b>		<b>Column shift (deg)</b>		<b>Tile Order</b>	
	2	2	5.0		72.0		0.0		0.0		DEFAULT	
<b>Dithers</b>	<b>#</b>	<b>Primary Dither Type</b>				<b>Primary Dithers</b>			<b>Subpixel Positions</b>			
	1	INTRAMODULEX				3			4-POINT-MEDIUM-WITH-NIRISS			
<b>Direct Image</b>	<b>NIRCam Wide Field Slitless Spectroscopy</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	F090W	F356W	SHALLOW4	10	1	1	526.102		GRISMR	Direct Image	1
<b>Spectral Elements</b>	<b>NIRCam Wide Field Slitless Spectroscopy</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>
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	2		F277W		NIS	11	1	12	12	5797.856
	3		F090W		NIS	12	1	1	1	526.102
	4		F277W		NIS	12	1	2	2	1052.203
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