



## 5664 - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

Cycle: 3, Proposal Category: GO

### INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Dr. Jorjyt Matthee (PI) (ESA Member)</b>	<b>Institute of Science and Technology Austria</b>
Dr. Daichi Kashino (CoI)	National Astronomical Observatory of Japan (NAOJ)
Dr. Ruari Mackenzie (CoI) (ESA Member)	EPFL
Prof. Robert Andrew Simcoe (CoI)	Massachusetts Institute of Technology
Dr. Rongmon Bordoloi (CoI)	North Carolina State University
Prof. Simon J. Lilly (CoI) (ESA Member)	Eidgenossische Technische Hochschule (ETH)
Prof. Anna-Christina Eilers (CoI) (US Admin CoI)	Massachusetts Institute of Technology
Dr. Rohan Naidu (CoI)	Massachusetts Institute of Technology
Dr. Romain Alexis Meyer (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Prof. Pascal Oesch (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Prof. John Chisholm (CoI)	University of Texas at Austin
Prof. Ivo Labbe (CoI)	Swinburne University of Technology
Prof. Jenny Emma Greene (CoI)	Princeton University
Prof. Garth D. Illingworth (CoI)	University of California - Santa Cruz
Dr. Irene Shivaiei (CoI) (ESA Member)	Centro de Astrobiologia (CSIC/INTA) Inst. Nac. de Tec. Aero.
Prof. Michael Maseda (CoI)	University of Wisconsin - Madison
Prof. Stijn Wuyts (CoI) (ESA Member)	University of Bath
Ivan Kramarenko (CoI) (ESA Member)	Institute of Science and Technology Austria
Gauri Kotiwale (CoI) (ESA Member)	Institute of Science and Technology Austria
Alberto Torralba (CoI) (ESA Member)	Universidad de Valencia, Observatorio Astronomico
Dr. Mengyuan Xiao (CoI) (ESA Member)	University of Geneva, Department of Astronomy

<i>Name</i>	<i>Institution</i>
Dr. Andrew Goulding (CoI)	Princeton University
Prof. Erica Nelson (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	GN-16813	NIRSpec IFU Spectroscopy	(1) GN-16813
	2	GS-13971	NIRSpec IFU Spectroscopy	(2) GS-13971
	4	GN-9771	NIRSpec IFU Spectroscopy	(4) GN-9771
	5	GN-12839	NIRSpec IFU Spectroscopy	(5) GN-12839
	7	GN-12839	NIRSpec IFU Spectroscopy	(5) GN-12839
	6	GN-15498	NIRSpec IFU Spectroscopy	(6) GN-15498

## ABSTRACT

The presence of supermassive black holes (SMBHs) in galaxies out to the highest redshifts is one of the key puzzles of observational astrophysics. Among the most surprising results of JWST so far has been the discovery of a population of relatively faint, optically red AGN at high-redshifts identified through broad H $\alpha$  emission in virtually every extra-galactic field. Their SMBH masses and UV luminosities are up to 100 times lower than high-redshift AGN found with wide-field ground-based surveys. While the AGN are red in the rest-frame optical, suggesting obscured early SMBH growth, a significant fraction of them has surprisingly blue UV colors. What is the origin of the UV emission? Does it originate from young stars in the host galaxy, or is it scattered light that can escape the AGN disks through holes in the dust? How common are galactic scale outflows, and is there a link between the UV emission, the properties of outflows and the AGNs? Here we aim to address these questions by performing deep NIRSpec IFU prism and high resolution grating spectroscopy of a carefully selected sample of faint AGN at  $z \sim 5.3$ . We will a) address the fraction of UV light due to scattered AGN light versus star formation of their host galaxy, and b) characterise the properties of outflows, and correlate these with the SMBH mass and the origin of the UV light. This allows us to address whether outflows from AGN activity may have driven openings in the dust that surrounds early SMBH growth, through which we can detect scattered UV light and through which AGN could have contributed to the end stages of the reionization of the Universe.

## OBSERVING DESCRIPTION

We will obtain deep NIRSpec IFU Prism and High resolution grating spectroscopy of a carefully selected sample of five faint AGN at redshifts  $z=5.1-5.5$  that display broad H $\alpha$  emission in NIRCам Grism data. The targets are spread over GOODS-N (5) and GOODS-S (1).

We will use the Prism mode to characterise the spatially resolved SED of the faint AGN and their host and companion galaxies over the full 1-5 micron range and we will use the G395H/F290LP mode to obtain sensitive high resolution spectra for the Hbeta, [OIII] and Halpha emission lines.

In the G395H/F290LP grating, we will obtain 8 exposures each using 31 Groups with the NRSIRS2 readout mode given the long required integration times and data-rate limitations. The 8 dithers are following a Medium cycling pattern that offer an optimal compromise between a large enough step size to mitigate microshutter failures, while ensuring good sub-pixel sampling and a large FoV  $\sim 2.5'' \times 2.5''$  that has the full exposure time. The total exposure time in such an 8 point dither is 18206 s. For the Prism observations, we use 55 Groups with the NRSIRS2RAPID readout mode for optimal cosmic ray removal yielding a total exposure time of 6535 s.

There are no PA constraints. None of the targets is close to any very bright source, meaning that we do not require leakcal exposures. Based on NIRCcam imaging, we judge that there are a sufficient number of object-free spaxels available to perform background estimates, such that no additional background exposures are needed. No target acquisition is included as the guide stars have GAIA astrometry and a pointing accuracy of 0.2'' is sufficient.

We have split the visits for GN-15498 in two, because we shift the pointing by 1.2'' along the x direction to minimise the fraction of the Halpha+[NII] line profile to fall in the chip gap with G395H. 30 Groups instead of 31 Groups to account for the increased overheads.

Proposal 5664 - Targets - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	GN-16813	RA: 12 36 43.0300 (189.1792917d) Dec: +62 17 33.12 (62.29253d) Equinox: J2000		
<i>Comments:</i> <i>Category=Galaxy</i> <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i>				
(2)	GS-13971	RA: 03 32 33.2600 (53.1385833d) Dec: -27 47 24.90 (-27.79025d) Equinox: J2000		
<i>Comments:</i> <i>Category=Galaxy</i> <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i>				
(4)	GN-9771	RA: 12 37 7.4427 (189.2810113d) Dec: +62 14 50.31 (62.24731d) Equinox: J2000		
<i>Comments:</i> <i>Category=Galaxy</i> <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i>				
(5)	GN-12839	RA: 12 37 22.6269 (189.3442788d) Dec: +62 15 48.11 (62.26336d) Equinox: J2000		
<i>Comments:</i> <i>Category=Galaxy</i> <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i>				
(6)	GN-15498	RA: 12 37 8.5300 (189.2855417d) Dec: +62 16 50.82 (62.28078d) Equinox: J2000		
<i>Comments:</i> <i>Category=Galaxy</i> <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i>				

Fixed Targets

Proposal 5664 - Observation 1 - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

Wed Nov 20 19:00:25 GMT 2024

<b>Observation</b>	<p><b>Proposal 5664, Observation 1: GN-16813</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRSpec IFU 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)	GN-16813	RA: 12 36 43.0300 (189.1792917d) Dec: +62 17 33.12 (62.29253d) Equinox: J2000									
	<p><i>Comments:</i>  <i>Category=Galaxy</i>  <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i></p>											
<b>Template</b>	<b>TA Method</b>											
	NONE											
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>		<b>Size</b>	<b>Starting Point</b>			<b>Number of Points</b>	<b>Points</b>			
	1	CYCLING		MEDIUM	1			8				
<b>Spectral Elements</b>	<b>#</b>	<b>Grating/Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Leakcal</b>	<b>Dither</b>	<b>Autocal</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1	G395H/F290LP	NRSIRS2	31	1	false	true	NONE	8	8	18206.935	
	2	PRISM/CLEAR	NRSIRS2RAPID	55	1	false	true	NONE	8	8	6535.823	

Proposal 5664 - Observation 2 - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

Wed Nov 20 19:00:25 GMT 2024

<b>Observation</b>	<p><b>Proposal 5664, Observation 2: GS-13971</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
<b>Diagnostics</b>	(Visit 2:1) 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>			
	(2)	GS-13971	RA: 03 32 33.2600 (53.1385833d) Dec: -27 47 24.90 (-27.79025d) Equinox: J2000									
	<p><i>Comments:</i>  <i>Category=Galaxy</i>  <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i></p>											
<b>Template</b>	<b>TA Method</b>											
	NONE											
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>		<b>Size</b>	<b>Starting Point</b>			<b>Number of Points</b>	<b>Points</b>			
	1	CYCLING		MEDIUM	1			8				
<b>Spectral Elements</b>	<b>#</b>	<b>Grating/Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Leakcal</b>	<b>Dither</b>	<b>Autocal</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1	G395H/F290LP	NRSIRS2	31	1	false	true	NONE	8	8	18206.935	
	2	PRISM/CLEAR	NRSIRS2RAPID	55	1	false	true	NONE	8	8	6535.823	

Proposal 5664 - Observation 4 - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

Wed Nov 20 19:00:25 GMT 2024

<b>Observation</b>	<b>Proposal 5664, Observation 4: GN-9771</b> <b>Diagnostic Status: Warning</b> Observing Template: NIRSpec IFU Spectroscopy											
	(Visit 4:1) 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>		
	(4)	GN-9771	RA: 12 37 7.4427 (189.2810113d) Dec: +62 14 50.31 (62.24731d) Equinox: J2000									
<i>Comments:</i> Category=Galaxy Description=[Active galactic nuclei, Emission line galaxies, Quasars]												
<b>Template</b>	<b>TA Method</b>											
	NONE											
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>		<b>Size</b>	<b>Starting Point</b>			<b>Number of Points</b>	<b>Points</b>			
	1	CYCLING		MEDIUM	1			8				
<b>Spectral Elements</b>	<b>#</b>	<b>Grating/Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Leakcal</b>	<b>Dither</b>	<b>Autocal</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1	G395H/F290LP	NRSIRS2	31	1	false	true	NONE	8	8	18206.935	
	2	PRISM/CLEAR	NRSIRS2RAPID	55	1	false	true	NONE	8	8	6535.823	

Proposal 5664 - Observation 5 - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

Wed Nov 20 19:00:25 GMT 2024

<b>Observation</b>	<p><b>Proposal 5664, Observation 5: GN-12839</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
<b>Diagnostics</b>	(Visit 5:1) 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>			
	(5)	GN-12839	RA: 12 37 22.6269 (189.3442788d) Dec: +62 15 48.11 (62.26336d) Equinox: J2000									
	<p><i>Comments:</i>  <i>Category=Galaxy</i>  <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i></p>											
<b>Template</b>	<b>TA Method</b>											
	NONE											
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>		<b>Size</b>	<b>Starting Point</b>			<b>Number of Points</b>	<b>Points</b>			
	1	CYCLING		MEDIUM	1			8				
<b>Spectral Elements</b>	<b>#</b>	<b>Grating/Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Leakcal</b>	<b>Dither</b>	<b>Autocal</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1	PRISM/CLEAR	NRSIRS2RAPID	55	1	false	true	NONE	8	8	6535.823	

Proposal 5664 - Observation 7 - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

Wed Nov 20 19:00:25 GMT 2024

<b>Observation</b>	<p><b>Proposal 5664, Observation 7: GN-12839</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
<b>Diagnostics</b>	(Visit 7:1) 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>			
	(5)	GN-12839	RA: 12 37 22.6269 (189.3442788d) Dec: +62 15 48.11 (62.26336d) Equinox: J2000									
	<p><i>Comments:</i>  <i>Category=Galaxy</i>  <i>Description=[Active galactic nuclei, Emission line galaxies, Quasars]</i></p>											
<b>Template</b>	<b>TA Method</b>											
	NONE											
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>		<b>Size</b>	<b>Starting Point</b>			<b>Number of Points</b>	<b>Points</b>			
	1	CYCLING		MEDIUM	1			8				
<b>Spectral Elements</b>	<b>#</b>	<b>Grating/Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Leakcal</b>	<b>Dither</b>	<b>Autocal</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1	G395H/F290LP	NRSIRS2	30	1	false	true	NONE	8	8	17623.379	
<b>Special Requirements</b>	Offset 1.2 arcsec, 0.0 arcsec											

Proposal 5664 - Observation 6 - Dissecting Little Red Dots: the connection between early SMBH growth and cosmic reionization

Wed Nov 20 19:00:25 GMT 2024

<b>Observation</b>	<b>Proposal 5664, Observation 6: GN-15498</b> <b>Diagnostic Status: Warning</b> Observing Template: NIRSpec IFU Spectroscopy											
	(Visit 6:1) 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>			
	(6)	GN-15498	RA: 12 37 8.5300 (189.2855417d) Dec: +62 16 50.82 (62.28078d) Equinox: J2000									
<i>Comments:</i> Category=Galaxy Description=[Active galactic nuclei, Emission line galaxies, Quasars]												
<b>Template</b>	<b>TA Method</b>											
	NONE											
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>		<b>Size</b>	<b>Starting Point</b>			<b>Number of Points</b>	<b>Points</b>			
	1	CYCLING		MEDIUM	1			8				
<b>Spectral Elements</b>	<b>#</b>	<b>Grating/Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Leakcal</b>	<b>Dither</b>	<b>Autocal</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1	G395H/F290LP	NRSIRS2	31	1	false	true	NONE	8	8	18206.935	
	2	PRISM/CLEAR	NRSIRS2RAPID	55	1	false	true	NONE	8	8	6535.823	