



8824 - Challenging Conventional Galaxy Formation: A Possible 500 km/s Velocity Dispersion at $z=2$

Cycle: 4, Proposal Category: GO

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Prof. Pieter van Dokkum (PI)	Yale University
Prof. Mariska Kriek (CoI) (ESA Member)	Universiteit Leiden

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1		NIRSpec IFU Spectroscopy	(1) 1256-0
	2		NIRSpec IFU Spectroscopy	(1) 1256-0

ABSTRACT

In 2009, a deep spectrum obtained with the Gemini telescope revealed that a compact galaxy at $z=2.2$ (1256-0) had a stellar velocity dispersion of 500 km/s, far exceeding any values found in local galaxies. This extraordinary result has faced skepticism due to the low signal-to-noise ratio of the original spectrum, significant formal uncertainties, and challenges reconciling such a high dispersion with the standard inside-out growth paradigm of massive galaxy evolution. However, recent JWST observations have begun to challenge traditional views, providing indirect evidence for an unexpected population of ultra-dense massive galaxies at $z=4-7$. If these early, ultra-dense galaxies indeed existed, 1256-0 could represent a direct descendant.

We propose using the NIRSpec IFU to acquire a high S/N spectrum of 1256-0 to determine the stellar velocity dispersion with a precision of 7–8%. Confirmation of its extreme velocity dispersion would unambiguously demonstrate the existence of ultra-dense galaxies with exceptionally deep potential wells in the early universe. Additionally, we aim to measure the galaxy's stellar age and metallicity through population synthesis, investigate

spatial variations in kinematics or stellar populations, and characterize the spatial extent and kinematics of its (weak) emission lines.

This small program has the potential to redefine our understanding of galaxy formation and the nature of massive galaxies at high redshift, providing new insights into the early universe's most extreme objects.

OBSERVING DESCRIPTION

We will use the NIRSPEC IFU, with the standard 4-point nod pattern for background modeling.

The galaxy is small enough, with an effective radius of 0.1", that a good background can be created from the standard nods.

The G140M/F100LP grating will be used as it provides sufficient spectral resolution and the optimal spectral range for kinematics and age measurements.

No acquisition is needed as the object is small and the position is known sufficiently well from an HST image.

Proposal 8824 - Targets - Challenging Conventional Galaxy Formation: A Possible 500 km/s Velocity Dispersion at z=2

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	1256-0	RA: 12 54 59.6270 (193.7484458d) Dec: +01 11 28.92 (1.19137d) Equinox: J2000	Epoch of Position: 2000	
<i>Comments:</i> Category=Galaxy Description=[Compact galaxies, Elliptical galaxies, High-redshift galaxies] Extended=YES					

Proposal 8824 - Observation 1 - Challenging Conventional Galaxy Formation: A Possible 500 km/s Velocity Dispersion at z=2

Thu May 21 15:00:17 GMT 2026

Observation	Proposal 8824, Observation 1 Diagnostic Status: Warning Observing Template: NIRSpec IFU Spectroscopy											
	(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)	1256-0	RA: 12 54 59.6270 (193.7484458d) Dec: +01 11 28.92 (1.19137d) Equinox: J2000			Epoch of Position: 2000						
<i>Comments:</i> Category=Galaxy Description=[Compact galaxies, Elliptical galaxies, High-redshift galaxies] Extended=YES												
Template	TA Method						HFF Readout Mode					
	NONE						false					
Dithers	#	Dither Type		Size	Starting Point		Number of Points		Points			
	1	4-POINT-NOD										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	G140M/F100LP	NRSIRS2	25	2	false	true	NONE	4	8	14705.601	225134

Proposal 8824 - Observation 2 - Challenging Conventional Galaxy Formation: A Possible 500 km/s Velocity Dispersion at z=2

Thu May 21 15:00:17 GMT 2026

Observation	Proposal 8824, Observation 2 Diagnostic Status: Warning Observing Template: NIRSpec IFU Spectroscopy <i>Comments: WOPR repeat of observation 1. See TTRBJWST-89605.</i>											
	(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.											
Diagnosics												
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous			
	(1)	1256-0	RA: 12 54 59.6270 (193.7484458d) Dec: +01 11 28.92 (1.19137d) Equinox: J2000			Epoch of Position: 2000						
<i>Comments:</i> Category=Galaxy Description=[Compact galaxies, Elliptical galaxies, High-redshift galaxies] Extended=YES												
Template	TA Method						HFF Readout Mode					
	NONE						false					
Dithers	#	Dither Type		Size	Starting Point		Number of Points		Points			
	1	4-POINT-NOD										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Ex p	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	G140M/F100LP	NRSIRS2	25	2	false	true	NONE	4	8	14705.601	225134