



# 6581 - Multi-Cycle monitoring of the volatile evolution of a returning planetesimal as it approaches perihelion

Cycle: 3, Proposal Category: GO

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Dr. Bryce Bolin (PI)</b>	<b>Eureka Scientific Inc.</b>
Dr. James M Bauer (CoI)	University of Maryland
Dr. Dennis Bodewits (CoI)	Auburn University
Dr. Michael E Brown (CoI)	California Institute of Technology
Dr. Christine Chen (CoI)	The Johns Hopkins University
Dr. Yanga Fernandez (CoI)	University of Central Florida Board of Trustees
Dr. Joel David Green (CoI)	Space Telescope Science Institute
Dr. Carey Michael Lisse (CoI)	The Johns Hopkins University Applied Physics Laboratory
Prof. Alessandro Morbidelli (CoI) (ESA Member)	Observatoire de la Cote d'Azur
Dr. Keith S. Noll (CoI)	Planetary Science Institute
Dr. Mohammad Saki (CoI)	University of Missouri - Saint Louis

## OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	NIRSpecIFU-UN271	NIRSpec IFU Spectroscopy	(1) C2014UN271-NEEDS-OFFSET
	2	NIRSpecIFU-UN271O FFSET	NIRSpec IFU Spectroscopy	(2) C2014UN271-OFFSET
	3	NIRSPEC-SW1/LW1- UN271	NIRCam Imaging	(3) C2014UN271-NO-OFFSET

## **ABSTRACT**

The 140 km diameter Oort Cloud comet C/2014 UN271 is likely one of the original planetesimals that formed in the protoplanetary disk and will reach a perihelion distance of  $\sim 10$  au in 2031. Recent NIRSpec observations of UN271 when it was 18.2 au from the Sun show that it produces considerable quantities of CO<sub>2</sub> and CO with icy grains. While CO can be active at  $\sim 18$  au, the detection of CO<sub>2</sub>, normally active inside 13 au, implies that the comet is hyperactive and may possess other cometary volatiles such as NH<sub>3</sub> and amorphous water ice which will become active or crystallize as the comet nears the Sun within the next couple of years. We propose a small multi-Cycle program of 24.66 h with JWST to take near-simultaneous observations of UN271 with NIRSpec and NIRCам to observe the evolution of its volatiles and ices over the next few years. The instruments will be complimentary with NIRSpec providing detailed spectral information the comets near-nucleus coma and NIRCам providing wide-field mapping of volatiles and ices. We will observe UN271 once per cycle with the first observation starting in June 2024 at the end of Cycle 2 when the comet is  $\sim 16.3$  au from the Sun and ending in June 2026 during Cycle 4 when the comet is 14 au from the Sun. Combined with public NIRSpec data, our observations will provide coverage of the comet over a  $\sim 4$  au range during which different cometary volatiles may become active such as NH<sub>3</sub> and and water ice can crystallize. Observing the evolution of UN271 will provide groundbreaking and exciting constraints on the the volatile contents and evolution of the original planetesimals and protoplanetary disk.

## **OBSERVING DESCRIPTION**

Our science program will consist of three visits at a cadence of once per Cycle for the next three Cycles 2-4. The first visit will occur at the end of Cycle 2 in June 2024, the second visit will occur at the end of Cycle 3 in June 2025 and the third visit will occur at the end of Cycle 4 in June 2026. The total time of one of our combined NIRSpec, NIRSpec offset and NIRCам visits is 8.22. We will be observing our target for three visits, once per Cycle for the next three Cycles for a total request of 24.66 h. Our observations will not need the Background Limited special requirement as the difference between the SNR assuming a high background and the low background at the sky location of UN271 during our expected date of observations is very small. We will request moving object support since our target is moving 10 arcsec/h, well below the rate of motion limit of JWST.

For our NIRSpec observations, we will use Prism/CLEAR mode and covers an area of 3 arcsec x 3 arcsec centered on the comet at a resolution of 0.1 arcseconds. We will observe using the NRS readout mode taking 21 groups/integrations, 1 integration per exposure with a 4-point dither with a total of 4 integrations for a total exposure time of  $\sim 3605$  seconds. This will provide a spectrum in each spaxel that has SNR of at least  $>30$  per spectral bin in our relevant wavelength region. The total duration of our observations is  $\sim 8,200$  s or 2.3 h. We will not use a target acquisition method because the ephemeris uncertainty of the comet is less than 1 arcsecond so the comet's optocenter will fit comfortably within the 3 arcsec field of view of the

NIRSpec IFU. We will observe our target with non-sidereal tracking. We will use offset observations for background removal and shadow observations if they become available.

For our NIRCам observations, we will use a single NIRCам module: Module B. We will use an offset of -55 arcsec, -35 arcsec to place our target in the center of NIRCам short wavelength detector B4. The angular size of short wavelength detector B4 is 64 arcsec x 64 arcsec. Thus our target, which is ~10 arcsec in size, will fit comfortably inside detector B4. We will use 6 dithers in INTRAMODULEX mode for flat field removal, PSF sampling, and avoidance of detector artifacts and bad pixels. The 6 INTRAMODULEX dithers will provide full coverage within a ~50 arcsec x 50 arcsec area that the comet will comfortably fit inside. The long wavelength channel will have perfect overlap within this region. Each NIRCам visit will consist of 8 sequences and 16 different filters. We will use the BRIGHT1 and RAPID readout modes.

Proposal 6581 - Targets - Multi-Cycle monitoring of the volatile evolution of a returning planetesimal as it approaches perihelion

Solar System Targets	#	Name	Level 1	Level 2	Level 3	
	(1)	C2014UN271-NEEDS-OFFSET	TYPE=COMET,Q=10.93467791995512,E=0.9987210 034936934,I=95.44173535654787 .O=189.9215982651115,W=326.368435598092,T=26- JAN- 2031:17:43:17,TTTimeScale=TDB,EQUINOX=J2000,E POCH=05-SEP-2021:00:00:00,EpochTimeScale=TDB			
	<i>Comments: Extended=YES</i>					
	(2)	C2014UN271-OFFSET	TYPE=COMET,Q=10.93467791995512,E=0.9987210 034936934,I=95.44173535654787 .O=189.9215982651115,W=326.368435598092,T=26- JAN- 2031:17:43:17,TTTimeScale=TDB,EQUINOX=J2000,E POCH=05-SEP-2021:00:00:00,EpochTimeScale=TDB	TYPE=POS_ANGLE,RAD=480,ANG=90,REF=SUN		
<i>Comments: Extended=YES</i>						
(3)	C2014UN271-NO-OFFSET	TYPE=COMET,Q=10.93467791995512,E=0.9987210 034936934,I=95.44173535654787 .O=189.9215982651115,W=326.368435598092,T=26- JAN- 2031:17:43:17,TTTimeScale=TDB,EQUINOX=J2000,E POCH=05-SEP-2021:00:00:00,EpochTimeScale=TDB				
<i>Comments: Extended=YES</i>						

Proposal 6581 - Observation 1 - Multi-Cycle monitoring of the volatile evolution of a returning planetesimal as it approaches perihelion

Tue Mar 24 17:00:11 GMT 2026

<b>Observation</b>	<b>Proposal 6581, Observation 1: NIRSpecIFU-UN271</b> <b>Diagnostic Status: Warning</b> Observing Template: NIRSpec IFU Spectroscopy Background Observations:[NIRSpecIFU-UN271OFFSET (Obs 2)]											
	(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (NIRSpecIFU-UN271 (Obs 1)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
<b>Diagnostics</b>												
<b>Solar System Targets</b>	#	Name	Level 1			Level 2			Level 3			
	(1)	C2014UN271-NEEDS-OFFSET	TYPE=COMET,Q=10.93467791995512,E=0.9987210 034936934,I=95.44173535654787 ,O=189.9215982651115,W=326.368435598092,T=26- JAN- 2031:17:43:17,TimeScale=TDB,EQUINOX=J2000,E POCH=05-SEP-2021:00:00:00,EpochTimeScale=TDB Comments: Extended=YES									
<b>Template</b>	TA Method						HFF Readout Mode					
	NONE						false					
<b>Dithers</b>	#	Dither Type		Size		Starting Point		Number of Points		Points		
	1	4-POINT-DITHER										
<b>Spectral Elements</b>	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
	1	G395H/F290LP	NRSIRS2RAPID	65	1	false	true	NONE	4	4	3851.467	
	2	G395M/F290LP	NRSIRS2RAPID	40	1	false	true	NONE	4	4	2392.578	
	3	G235M/F170LP	NRSIRS2RAPID	20	1	false	true	NONE	4	4	1225.467	
	4	G140M/F100LP	NRSIRS2RAPID	20	1	false	true	NONE	4	4	1225.467	
<b>Special Requirements</b>	Between Dates 15-MAY-2026:00:00:00 and 07-SEP-2026:00:00:00											
	Sequence Observations 2, 1, 3 (reordered), Non-interruptible											
	DEFAULT WINDOW: ANGULAR RATE C2014UN271-NEEDS-OFFSET FROM JWST LESS THAN 0.075											

Proposal 6581 - Observation 2 - Multi-Cycle monitoring of the volatile evolution of a returning planetesimal as it approaches perihelion

Tue Mar 24 17:00:11 GMT 2026

<b>Observation</b>	<b>Proposal 6581, Observation 2: NIRSpecIFU-UN271OFFSET</b> <b>Diagnostic Status: Warning</b> Observing Template: NIRSpec IFU Spectroscopy Background Observation For: [NIRSpecIFU-UN271 (Obs 1)]											
	(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (NIRSpecIFU-UN271OFFSET (Obs 2)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
<b>Diagnostics</b>												
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>				<b>Level 2</b>				<b>Level 3</b>	
	(2)	C2014UN271-OFFSET	TYPE=COMET,Q=10.93467791995512,E=0.9987210 034936934,I=95.44173535654787 ,O=189.9215982651115,W=326.368435598092,T=26- JAN- 2031:17:43:17,TimeScale=TDB,EQUINOX=J2000,E POCH=05-SEP-2021:00:00:00,EpochTimeScale=TDB  <i>Comments: Extended=YES</i>				TYPE=POS_ANGLE,RAD=480,ANG=90,REF=SUN					
<b>Template</b>	<b>TA Method</b>						<b>HFF Readout Mode</b>					
	NONE						false					
<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	2-POINT-NOD										
<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>Optional ETC ID</b>
	1	G395H/F290LP	NRSIRS2RAPID	65	1	false	true	NONE	2	2	1925.733	
	2	G395M/F290LP	NRSIRS2RAPID	40	1	false	true	NONE	2	2	1196.289	
	3	G235M/F170LP	NRSIRS2RAPID	20	1	false	true	NONE	2	2	612.733	
	4	G140M/F100LP	NRSIRS2RAPID	20	1	false	true	NONE	2	2	612.733	
<b>Special Requirements</b>	Between Dates 15-MAY-2026:00:00:00 and 07-SEP-2026:00:00:00											
	Sequence Observations 2, 1, 3 (reordered), Non-interruptible											
	DEFAULT WINDOW: ANGULAR RATE C2014UN271-OFFSET FROM JWST LESS THAN 0.075											

Proposal 6581 - Observation 3 - Multi-Cycle monitoring of the volatile evolution of a returning planetesimal as it approaches perihelion

Tue Mar 24 17:00:11 GMT 2026

<b>Observation</b>	<b>Proposal 6581, Observation 3: NIRSPEC-SW1/LW1-UN271</b> <b>Diagnostic Status: Warning</b> Observing Template: NIRCcam Imaging									
	(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (NIRSPEC-SW1/LW1-UN271 (Obs 3)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.									
<b>Diagnostics</b>										
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>					
	(3)	C2014UN271-NO-OFFSET	TYPE=COMET,Q=10.93467791995512,E=0.9987210 034936934,I=95.44173535654787 .O=189.9215982651115,W=326.368435598092,T=26- JAN- 2031:17:43:17,TimeScale=TDB,EQUINOX=J2000,E POCH=05-SEP-2021:00:00:00,EpochTimeScale=TDB				<i>Comments: Extended=YES</i>			
<b>Template</b>	<b>Module</b>			<b>Subarray</b>						
	B			FULL						
<b>Dithers</b>	<b>#</b>	<b>Primary Dither Type</b>	<b>Primary Dithers</b>	<b>Subpixel Dither Type</b>	<b>Dither Size</b>	<b>Subpixel Positions</b>				
	1	INTRAMODULEX	4	STANDARD		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 Dithers</b>	<b>Total Exposure Time</b>	<b>Optional ETC ID</b>
	1	F070W	F460M	RAPID	10	1	4	4	429.471	
	2	F070W	F430M	RAPID	10	1	4	4	429.471	
	3	F070W	F335M	RAPID	10	1	4	4	429.471	
	4	F070W	F250M	RAPID	5	1	4	4	214.735	
<b>Special Requirements</b>	Between Dates 15-MAY-2026:00:00:00 and 07-SEP-2026:00:00:00 Offset 38.0 arcsec, 38.0 arcsec  Sequence Observations 2, 1, 3 (reordered), Non-interruptible  DEFAULT WINDOW: ANGULAR RATE C2014UN271-NO-OFFSET FROM JWST LESS THAN 0.075									