



17215 - Asteroid Bennu Large Particle Trail

Cycle: 30, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Dr. David Jewitt (PI) (Contact)	University of California - Los Angeles
Dr. Jing Li (CoI)	University of California - Los Angeles
Max Mutchler (CoI) (Contact)	Space Telescope Science Institute
Dr. Yoonyoung Kim (CoI)	University of Arizona
Dr. Jessica Agarwal (CoI) (ESA Member)	Technische Universität Braunschweig

VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:15.0	yes
02	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:15.0	yes
03	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:16.0	yes
04	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:16.0	yes
05	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:16.0	yes
06	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:17.0	yes
07	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:17.0	yes
08	(1) BENNU	WFC3/UVIS	1	24-Jul-2023 16:00:17.0	yes

8 Total Orbits Used

ABSTRACT

The sporadic ejection of centimeter sized particles from Bennu was one of the major surprises from NASA's OSIRIS-REx mission and revealed this object as one of the Active Asteroids. The cause of particle ejection is not yet well established. Archival data obtained for another purpose in 2012 show evidence for an ultra-faint, narrow particle trail that likely corresponds to the summed emission from Bennu over months. We propose to image the ultra-faint particle trail from asteroid Bennu at a more favorable geometry in order to better assess the properties of the trail. Through models, we will interpret the trail parameters to determine the average particle size, ejection speed, mass loss profile and mass, in order to better constrain the mass loss process.

OBSERVING DESCRIPTION

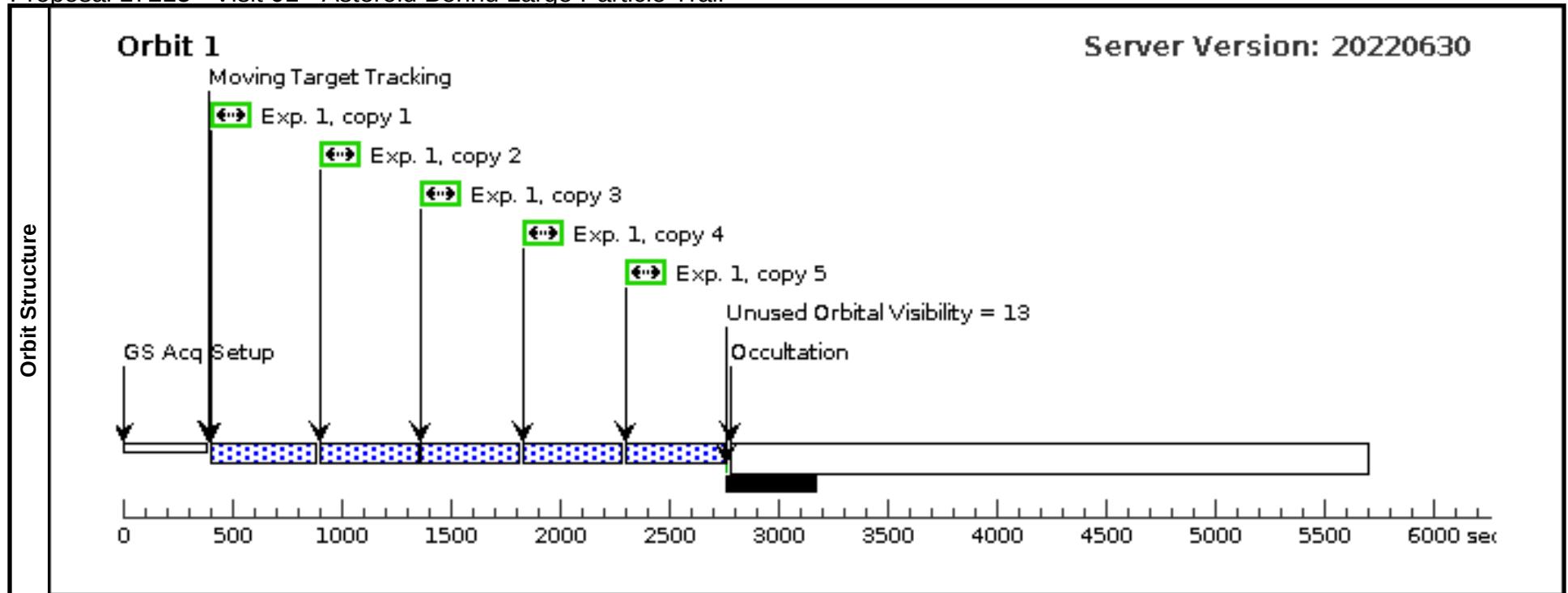
We request 8 HST orbits to begin an investigation of these questions. The need for 8 orbits is based on analysis of the archival data, showing the trail to be very faint (in 6 orbits) and the assumption that the trail production rate in 2023 is the same as in 2012. In 8 orbits we estimate that the trail signal-to-noise ratio will be <1 per pixel but, with a measurable trail length of 200 to 300 pixels, the integrated SNR is 14 to 17, and there will be enough SNR to measure resolved perpendicular segments and parallel profiles of the trail. The orbits should be as close together as possible but do not suffer from modest gaps, for example as may be needed for gyro-resets. In each orbit we will take five long exposures using WFC3 with the wide bandpass filter F350LP for maximum sensitivity - this time request and set up is similar to that used in the earlier program GO 13118. The F350LP filter provides a 1.6x higher count rate than more standard (e.g. R, V) filters for a target with a solar-type spectrum, which matters because we are interested in ultrafaint, diffuse emission near Bennu. We will dither the exposures to mitigate the effects from bad pixels, cosmic rays, and the inter-chip gap. The timing of the visit is determined by optimizing the geometry. We would like to observe Bennu from a vantage point in the orbital plane of the asteroid. In this geometry, all low velocity particles (which are confined to move close to the orbit plane) are lined up along the line of sight, so maximizing the surface brightness and detectability. (Depending on the thickness perpendicular to the orbit plane and the exact value of the angle of the Earth from the plane, we estimate an increase in the surface brightness by factors from 100 to 1000, offering a considerable observational advantage). In addition, we would like to minimize the geocentric distance, so as to better resolve the particle trail. The thickness of the trail provides a projection-free measure of the out-of-plane extent of the dust and of the perpendicular ejection speed. And we would like to minimize the heliocentric distance because spacecraft data suggest that particle emission is slightly stronger at small r_H than at large r_H (Hergenrother et al. 2020).

These conditions are best met on UT 2023 September 25. The Earth crosses the orbit plane on two occasions in 2023: on UT March 23 and September 25. The second of these crossings is the better of the two, in view of the much smaller geocentric distance (0.55 AU on September 25

compared to 1.37 AU on March 23). The heliocentric distance is also better (0.92 AU on September 25 against 1.35 AU on March 23). By the inverse square law, the geometry gives a 2.8 magnitude advantage to observations on September 25. This is slightly decreased by the larger phase angle on the latter date. However, Hergenrother et al. report that the phase function of Bennu particles is small, reducing the photometric advantage of the September 25 crossing to a still respectable 2.3 magnitudes (factor of 8 in flux density). We also note that the phase function of the particles is smaller than that of Bennu itself, acting to reduce the relative brightness of Bennu compared to a dust trail by a further $V = 1.04$ magnitudes relative to the March 23 date. For these reasons, we request observations at the plane-crossing on UT 2023 September 25. Bennu has been unobservable as a result of being in the HST Sun exclusion zone since 2019 September 15. It will emerge on UT 2023 February 9 and remain accessible throughout Cycle 30. The apparent rates of motion in late September are 180 arcsec/hr N and -15 arcsec/hr S, which are easily within Hubble's tracking capabilities. The ephemeris uncertainty is <1 arcsec, which is negligible compared to the WFC3 field-of-view. Ephemeris issues are of no concern to this observation. We understand that we may have essentially no control over the spacecraft roll angle, which means we will not be able to optimize the orientation of the dust tail on the CCD (i.e., to orient the tail along the longest dimension of the detector). However, the field-of-view of the camera is large enough that we should obtain excellent data, no matter what spacecraft roll angle is used. As described above, we request that the observations be obtained as close as possible to UT 2023 September 25. The actual moment of plane crossing is UT 2023 September 25.7. Dates within ± 1 day of plane crossing are sufficient to negate the effects of projection. Therefore we request 8 orbits in the window UT 2023 September 25.7 ± 1 day.

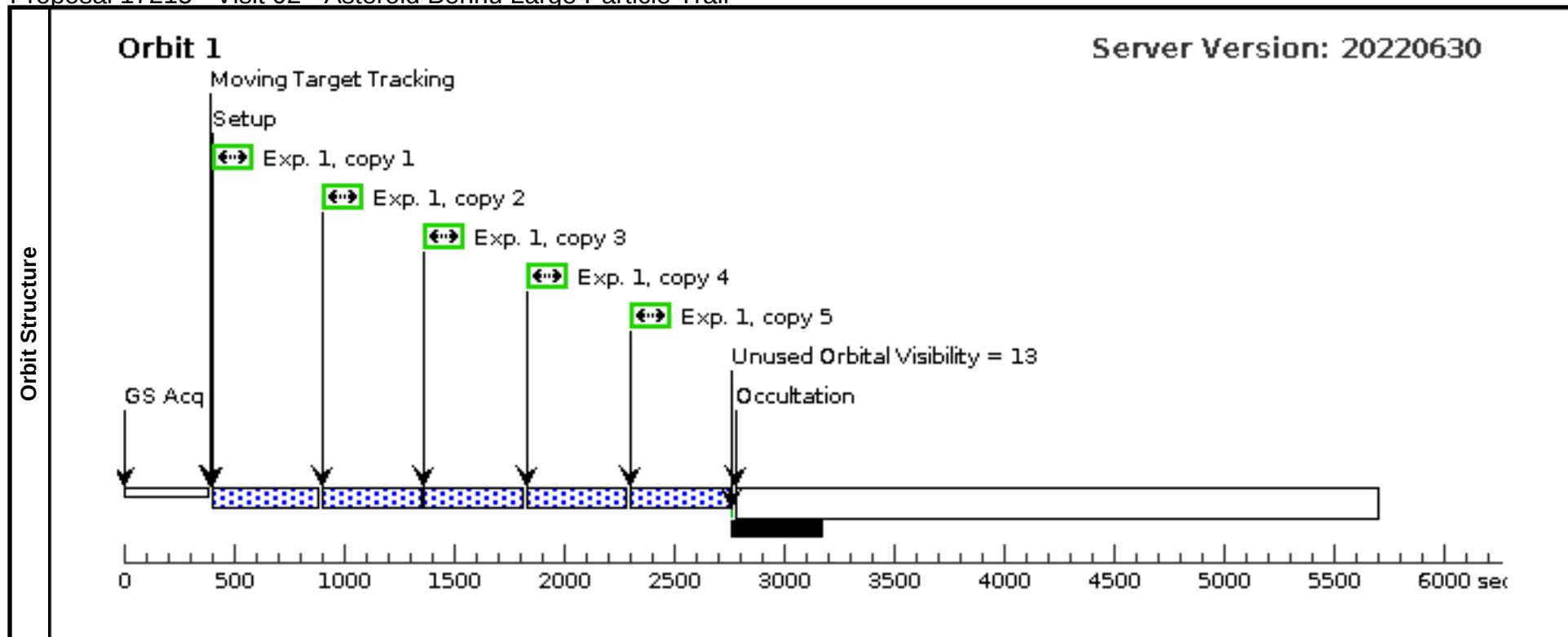
Proposal 17215 - Visit 01 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 01, implementation										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: BETWEEN 24-SEP-2023:16:00:00 AND 26-SEP-2023:17:00:00; SEQ 01,02,03,04,05,06,07,08 WITHIN 2 D											
Diagnosics	(Visit 01) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
	(1)	BENNU	TYPE=ASTEROID,A=1.12639102589 48120,E=0.2037450762416414,I=6.03 49437702479403 ,O=2.060866195696420,W=66.223060 84084298,M=101.7039520024729,EQ UINOX=J2000,EPOCH=01-JAN- 2011:00:00:00,EpochTimeScale=TDB, A1=0.,A2=0.,A3=0.					EARTH				
	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]		Orbit	
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP			Sequence 1-1 Non-Int in Visit 01	290 Secs X 5 (1450 Secs)			
									[>=>(Copy 1)] [>=>(Copy 2)] [>=>(Copy 3)] [>=>(Copy 4)] [>=>(Copy 5)]		[1]	



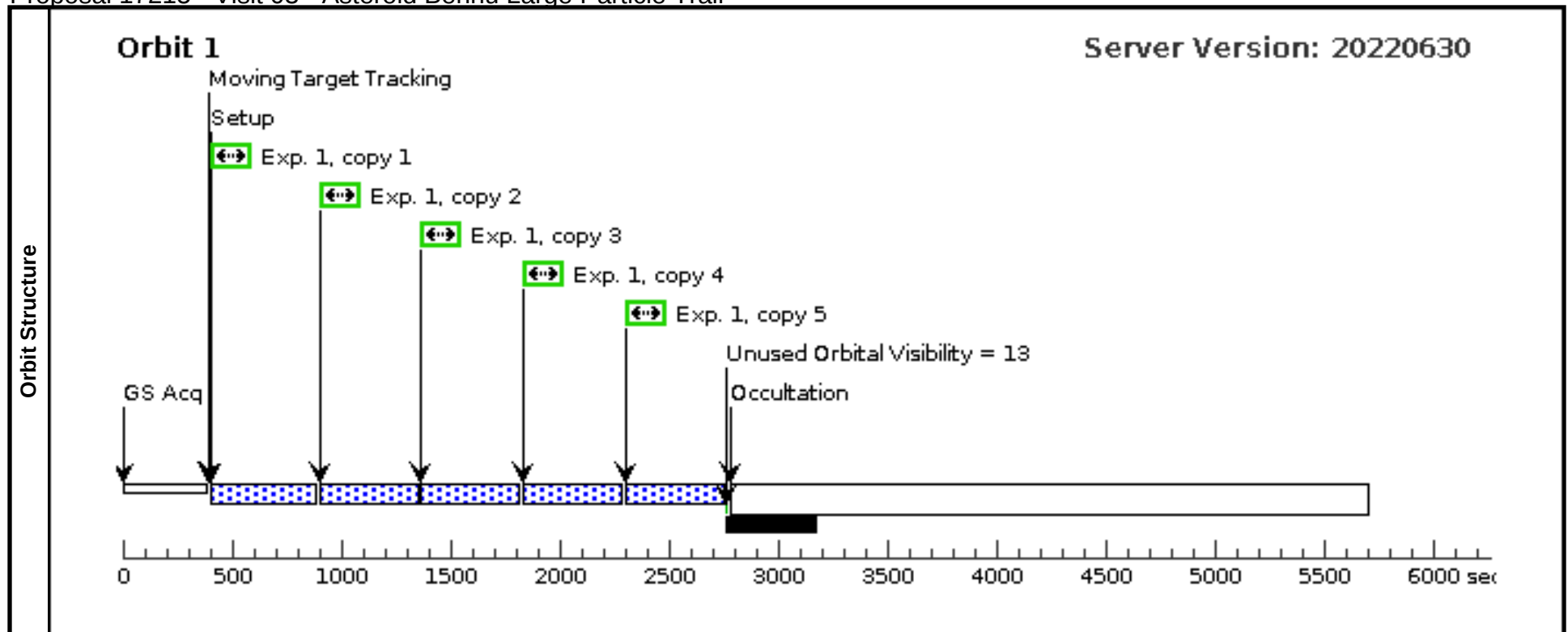
Proposal 17215 - Visit 02 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 02, implementation										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: (none)											
Diagnosics	(Visit 02) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
	(1)	BENNU	TYPE=ASTEROID,A=1.12639102589 48120,E=0.2037450762416414,I=6.03 49437702479403 ,O=2.060866195696420,W=66.223060 84084298,M=101.7039520024729,EQ UINOX=J2000,EPOCH=01-JAN- 2011:00:00:00,EpochTimeScale=TDB, A1=0.,A2=0.,A3=0.					EARTH				
	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit		
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 0.2,0.2	Sequence 1-1 Non-In t in Visit 02	290 Secs X 5 (1450 Secs)			
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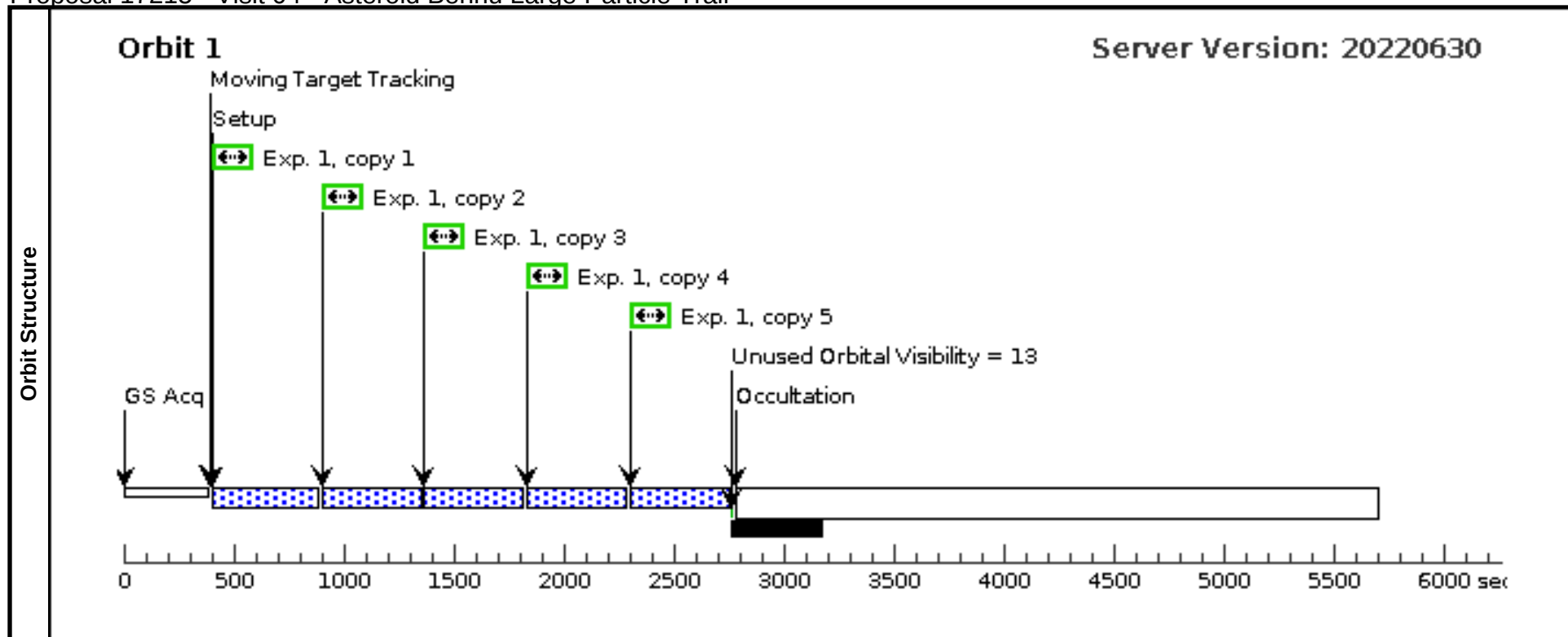
Proposal 17215 - Visit 03 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 03, implementation										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: BETWEEN 24-SEP-2023:16:00:00 AND 26-SEP-2023:17:00:00											
Diagnosics	(Visit 03) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
	(1)	BENNU	TYPE=ASTEROID,A=1.12639102589 48120,E=0.2037450762416414,I=6.03 49437702479403 ,O=2.060866195696420,W=66.223060 84084298,M=101.7039520024729,EQ UINOX=J2000,EPOCH=01-JAN- 2011:00:00:00,EpochTimeScale=TDB, A1=0.,A2=0.,A3=0.					EARTH				
	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit		
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 0.4,0.4	Sequence 1-1 Non-In t in Visit 03	290 Secs X 5 (1450 Secs)			
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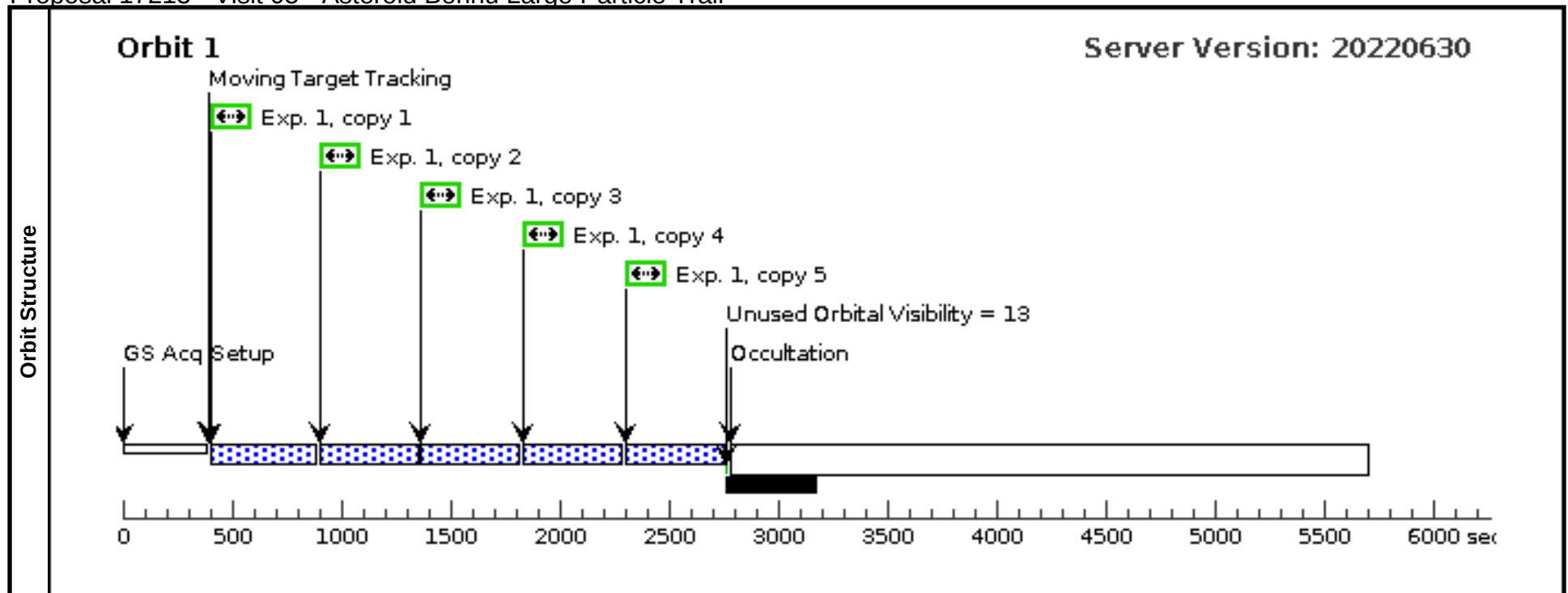
Proposal 17215 - Visit 04 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 04, implementation										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: (none)											
Diagnostics	(Visit 04) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
	(1)	BENNU	TYPE=ASTEROID,A=1.12639102589 48120,E=0.2037450762416414,I=6.03 49437702479403 ,O=2.060866195696420,W=66.223060 84084298,M=101.7039520024729,EQ UINOX=J2000,EPOCH=01-JAN- 2011:00:00:00,EpochTimeScale=TDB, A1=0.,A2=0.,A3=0.					EARTH				
	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit		
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 0.6,0.6	Sequence 1-1 Non-In t in Visit 04	290 Secs X 5 (1450 Secs)			
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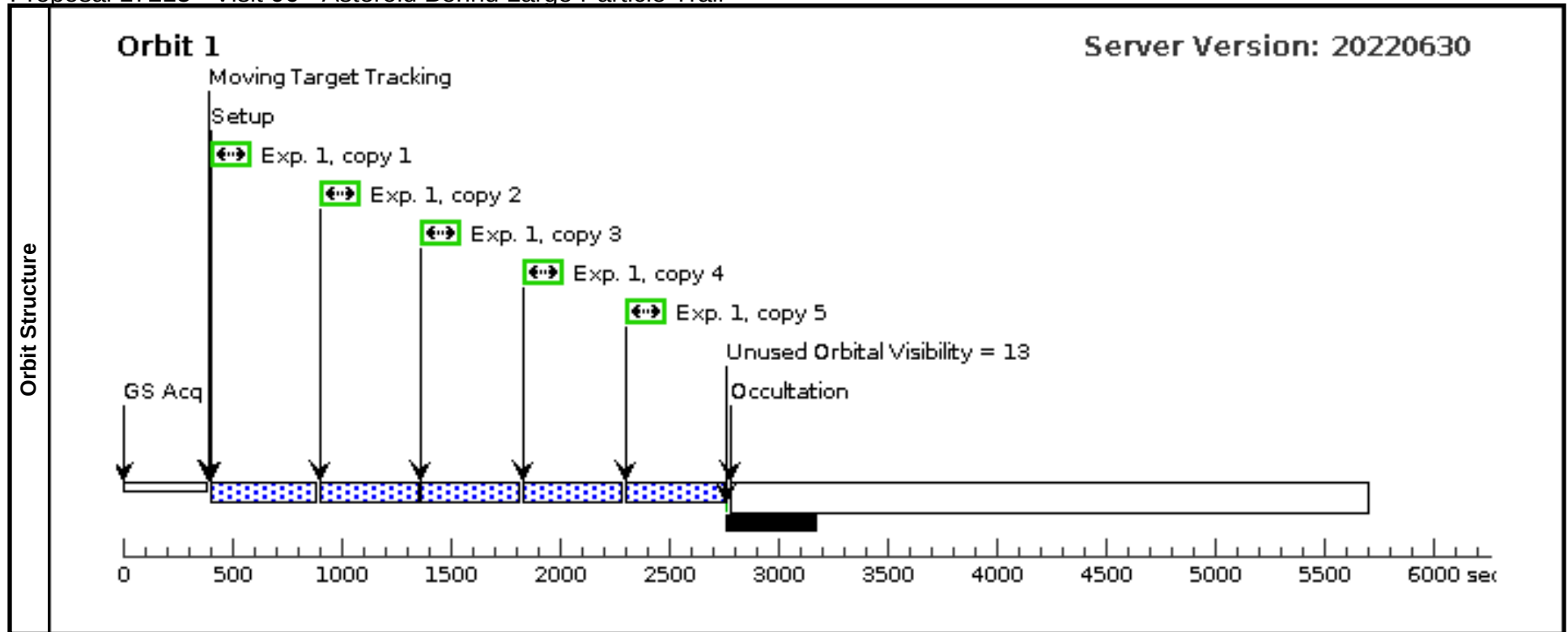
Proposal 17215 - Visit 05 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 05										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: BETWEEN 24-SEP-2023:16:00:00 AND 26-SEP-2023:17:00:00											
Diagnosics	(Visit 05) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
	(1)	BENNU	TYPE=ASTEROID,A=1.12639102589 48120,E=0.2037450762416414,I=6.03 49437702479403 ,O=2.060866195696420,W=66.223060 84084298,M=101.7039520024729,EQ UINOX=J2000,EPOCH=01-JAN- 2011:00:00:00,EpochTimeScale=TDB, A1=0.,A2=0.,A3=0.					EARTH				
	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit		
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 0.8,0.8	Sequence 1-1 Non-In t in Visit 05	290 Secs X 5 (1450 Secs)			
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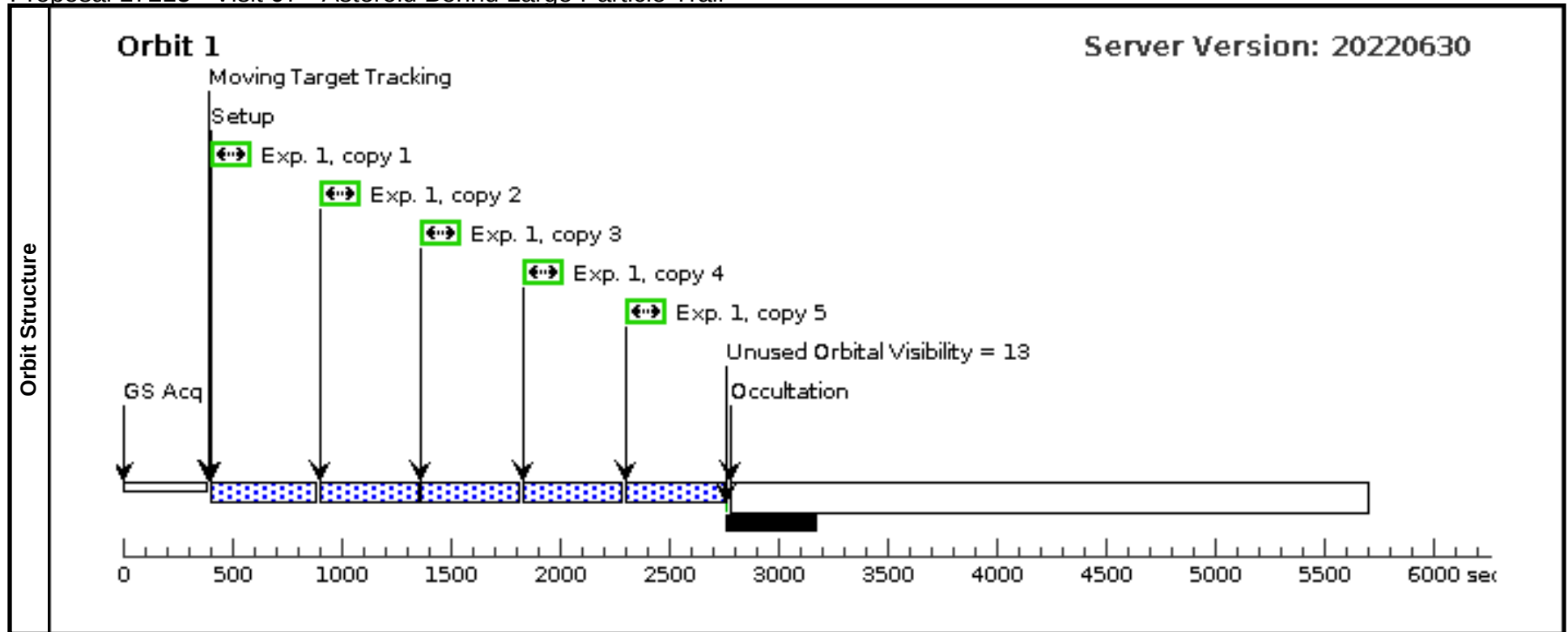
Proposal 17215 - Visit 06 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 06										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: (none)											
Diagnos	(Visit 06) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
	(1)	BENNU	TYPE=ASTEROID,A=1.12639102589 48120,E=0.2037450762416414,I=6.03 49437702479403 ,O=2.060866195696420,W=66.223060 84084298,M=101.7039520024729,EQ UINOX=J2000,EPOCH=01-JAN- 2011:00:00:00,EpochTimeScale=TDB, A1=0.,A2=0.,A3=0.					EARTH				
	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]		Orbit	
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 1.0,1.0	Sequence 1-1 Non-In t in Visit 06	290 Secs X 5 (1450 Secs)			
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Proposal 17215 - Visit 07 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 07										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: BETWEEN 24-SEP-2023:16:00:00 AND 26-SEP-2023:17:00:00											
Diagnos	(Visit 07) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
	(1)	BENNU	TYPE=ASTEROID,A=1.12639102589 48120,E=0.2037450762416414,I=6.03 49437702479403 ,O=2.060866195696420,W=66.223060 84084298,M=101.7039520024729,EQ UINOX=J2000,EPOCH=01-JAN- 2011:00:00:00,EpochTimeScale=TDB, A1=0.,A2=0.,A3=0.					EARTH				
	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit		
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 1.2,1.2	Sequence 1-1 Non-In t in Visit 07	290 Secs X 5 (1450 Secs)			
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Proposal 17215 - Visit 08 - Asteroid Bennu Large Particle Trail

Visit	Proposal 17215, Visit 08										Mon Jul 24 20:00:18 GMT 2023	
	Diagnostic Status: Informational											
	Scientific Instruments: WFC3/UVIS											
	Special Requirements: (none)											
Diagnos	(Visit 08) Informational (Form): The Visit Planner and Spike may produce different schedulability results.											
Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center					
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	Comments: Description=Active asteroid visited by the OSIRIS-REx spacecraft Extended=NO											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit		
	1		(1) BENNU	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 1.4,1.4	Sequence 1-1 Non-In t in Visit 08	290 Secs X 5 (1450 Secs)			
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