



# 17289 - Macroscopic Debris from the DART impact

Cycle: 30, Proposal Category: GO

(Availability Mode: SUPPORTED)

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
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Dr. Yoonyoung Kim (CoI) (ESA Member)	Technische Universität Braunschweig	yoonyoung.kim@tu-bs.de

## 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) DIDYMOS	WFC3/UVIS	1	05-Dec-2022 11:02:19.0	yes
02	(1) DIDYMOS	WFC3/UVIS	1	05-Dec-2022 11:02:20.0	yes
03	(1) DIDYMOS	WFC3/UVIS	1	05-Dec-2022 11:02:21.0	yes
04	(1) DIDYMOS	WFC3/UVIS	1	05-Dec-2022 11:02:22.0	yes

4 Total Orbits Used

## ABSTRACT

The NASA DART impact into one component of the Didymos/Dimorphos binary asteroid occurred on UT 2022 September 26. Images taken at the impact time show a spectacular, structured cloud of ejecta and, on later dates, the emergence of a long, radiation-pressure swept tail of particles.

Here, we propose a 4 orbit program to observe the DART-produced debris some 10 weeks after the impact, from a perspective within the projected orbit plane of the system. This observing geometry, in conjunction with an existing dynamics model, will provide a unique measure of the quantity

Proposal 17289 (STScI Edit Number: 9, Created: Monday, December 5, 2022 at 11:02:22 AM Eastern Standard Time) - Overview and of the size and velocity distributions of the larger ejecta particles, and we also expect to detect individual macroscopic fragments (boulders) in the ejecta trail. The measurement is highly complementary to the 19 orbit HST program GO 16674, whose final observation was taken on October 15. The proposed observation will extend the time base of data from less than three weeks to ten, and provide the strongest ejection constraints and the ultimate record of this unique impact experiment. Having an exactly known impact time and projectile energy, the DART impact also provides an important means to interpret existing and future observations of colliding asteroids, which are also known to produce structured ejecta fields and long trails of debris.

## **OBSERVING DESCRIPTION**

The science objectives can be met using 4 orbits on HST with WFC3, scheduled to occur as the Earth crosses the projected orbital plane. We considered a larger request for time at additional, later epochs. However, the syndynes and synchrones collapse together at later dates, providing little additional information, and the Didymos system will become progressively fainter as the distances from Sun and Earth increase. We are confident that ours is an efficient program focused on a necessary measurement. We propose to use the F350LP filter for these observations. This long-pass filter has very broad spectral coverage (FWHM  $>4000$  Å) and provides maximum sensitivity to continuum sources. It has become the standard filter for numerous Hubble GO observations of faint solar system targets, from asteroids and comet nuclei to Kuiper belt objects. Our plan is to obtain dithered images (to escape the effects of bad pixels and the inter-chip gap) with five images per orbit having exposure times of 300 s each. Because the impact-associated dust trail is expected to be very long, we will use the full WFC3 CCD readout, providing a 160 160 arcsec field of view (about 20,000 km if observations are taken at the optimum epoch of UT 2022 December 5). Use of the online WFC3 Exposure Time Calculator indicates that this procedure will yield a point source 5 sensitivity for objects at magnitude  $V = 26.8$ . Depending on the unknown dust trail surface brightness distribution, the obtained sensitivity might be slightly degraded relative to the model value owing to added noise. A  $V = 26.8$  magnitude object at the observing geometry of December 5 and having the 15 percent albedo of Dimorphos would have spherical equivalent radius 2.5 m, similar to the sizes of the larger boulders imaged on the surface by DART. Prior observations of moving objects from archived data show that the limiting magnitude is in practice set by interference from trailed field objects, a problem which does not affect observations of stars and galaxies where no trailing is involved. The non-sidereal RA motion of Didymos on UT December 5, for instance, varies from -200 hour 1 to +160 hour 1, as seen from HST. The non-sidereal DEC motion is of the same order. At 200 hour 1, field objects are dragged across the CCD by 400 pixels in 300s. Galaxies are a particular nuisance, since their diffuse, large-scale and structured brightness is impossible to mask. The best protection from degradation of the sensitivity by trailed objects in the background is provided by obtaining more data with different and uncorrelated backgrounds. Repeated detection of fragments in different orbits, for example, provides rock solid confidence that these objects are real and not noise peaks in the data. For this reason, and given the singular nature of this opportunity to observe the DART produced ejecta distribution, we request 4 orbits with WFC3 and the

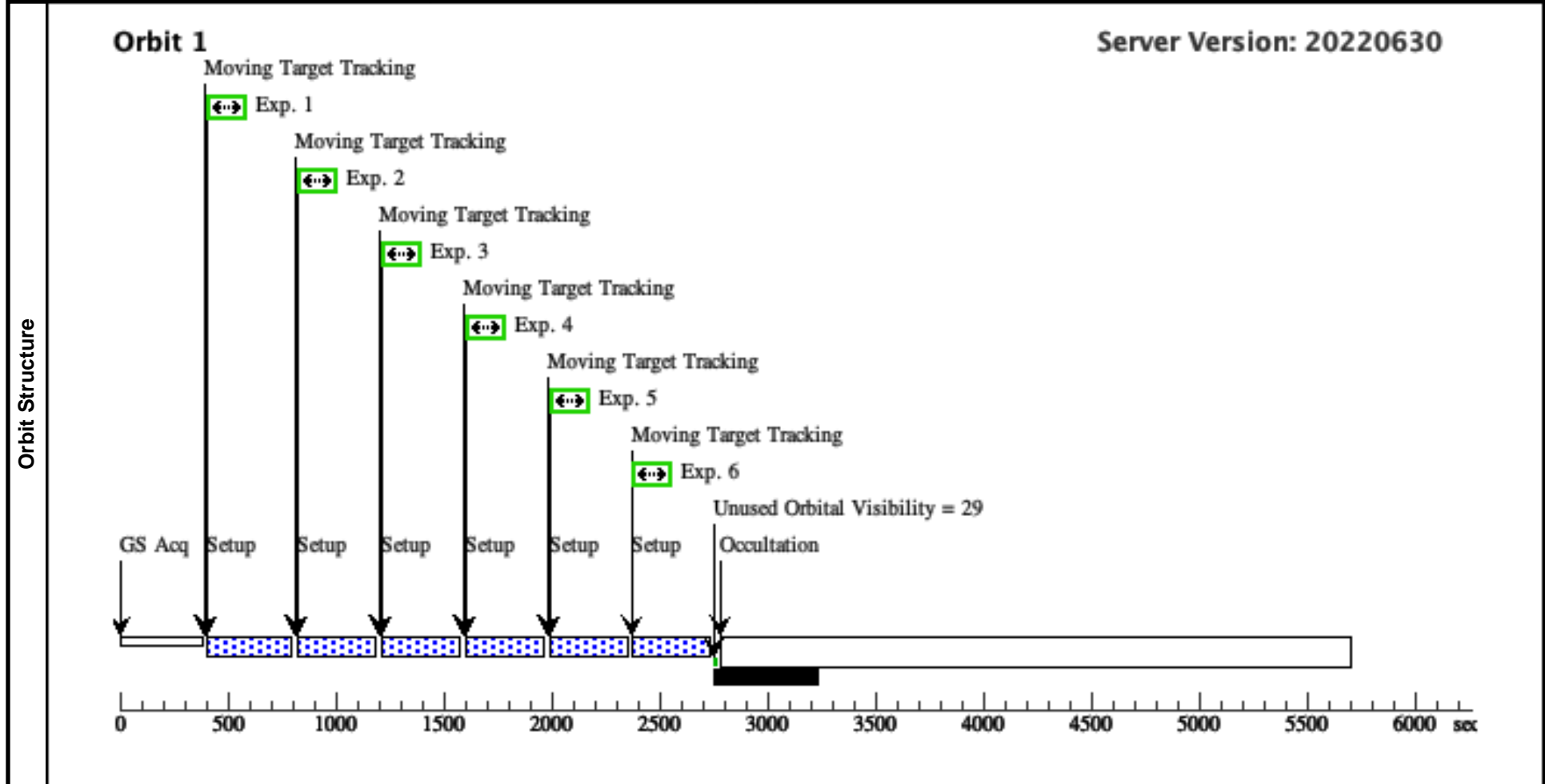
Proposal 17289 (STScI Edit Number: 9, Created: Monday, December 5, 2022 at 11:02:22 AM Eastern Standard Time) - Overview

F350LP filter. The requested orbits represent a 20% addition to Hubble time already allocated to the study of the debris field, and provide unique information on the properties of the largest particles ejected by the spacecraft impact. Use of the same filter also provides continuity with the near-impact data obtained under GO 16674. The ephemeris uncertainties are well below 1 arcsec and have no impact on the planned observations. The Earth crosses the projected orbit plane of the Didymos pair on two occasions before the solar elongation shrinks into the HST Sun exclusion zone of 55 deg. The first crossing, on UT 2022 December 5, is preferable for two reasons; 1) the earlier observation will sample the debris some 70 days after impact, from a geometry not very different from that at the impact epoch (other than the smaller out-of-plane angle), 2) the later crossing, on UT 2023 June 5, will suffer from substantial loss of sensitivity as a result of the larger heliocentric and geocentric distances (rH 2 AU vs. 1.1 and 0.2 AU on December 5). We estimate this loss at about 3.3 magnitudes. The linear resolution corresponding to the 0.08 arcsec HST PSF will also be considerably worse at the later plane crossing (116 km vs. 10 km on December 5). For these reasons, we request observations as near as possible to the UT 2022 December 5 plane crossing. The out-of-plane angle is  $<1^\circ$  from December 2 to 9, and observations in this period are requested. At earlier and later dates, the unique projection-free perspective on the vertical distribution of material in the trail and on the fragments, will be progressively degraded. Therefore, we request 4 orbits in the UT 2022 December 2-9 window, preferably scheduled close to December 5.

Proposal 17289 - Visit 01 - Macroscopic Debris from the DART impact

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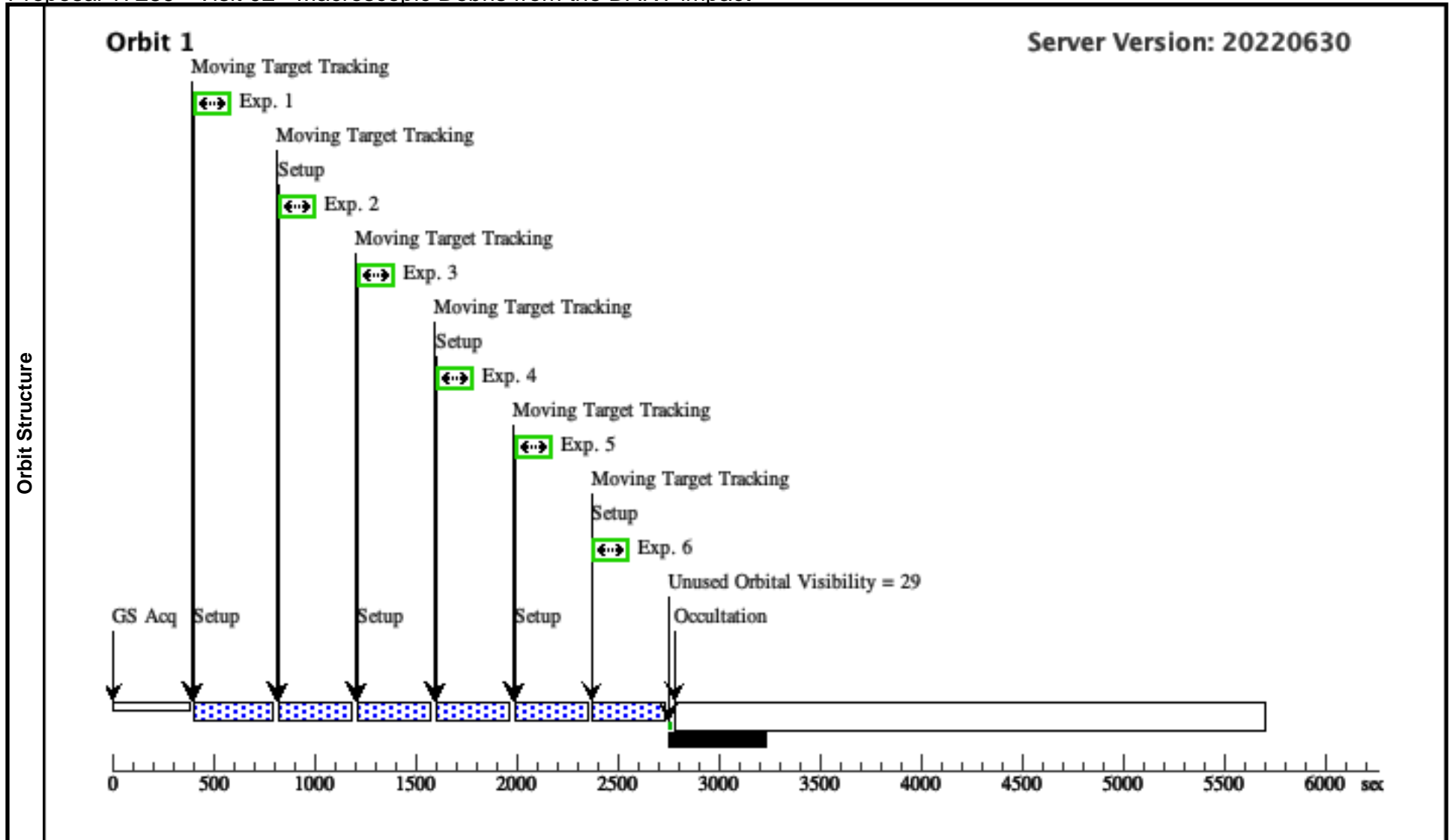
<b>Visit</b>	<b>Proposal 17289, Visit 01, implementation</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: WFC3/UVIS Special Requirements: ORIENT 267D TO 287 D; BEFORE 08-JAN-2023:00:00:00; SEQ 01.02.03.04 WITHIN 12 H									
	<b>Diagnostics</b>	(Exposure 1 (Sequence 1-6 Non-Int in Visit 01)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser								
(Exposure 2 (Sequence 1-6 Non-Int in Visit 01)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 3 (Sequence 1-6 Non-Int in Visit 01)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 4 (Sequence 1-6 Non-Int in Visit 01)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 5 (Sequence 1-6 Non-Int in Visit 01)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 6 (Sequence 1-6 Non-Int in Visit 01)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	DIDYMOS	TYPE=ASTEROID,A=1.64340118643 9353,E=0.3836403201185644,I=3.413 079835162661 .O=73.0031688833396,W=319.550049 5128057,M=1.263702528507169,EQU INOX=J2000,EPOCH=24-OCT- 2022:12:00:00,EpochTimeScale=TDB, R0=1. .A1=0.,A2=-1.101805196413E- 14,A3=0. .ALN=1.,NM=2.,NN=0.,NK=0.,AMR AT=0.					EARTH		
Comments: Description=Binary asteroid (65803) Didymos Extended=NO										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15,15	Sequence 1-6 Non-Int in Visit 01	193 Secs (193 Secs) [==>]	[1]
	2	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15,15; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 01	193 Secs (193 Secs) [==>]	[1]
	3	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15,15; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 01	193 Secs (193 Secs) [==>]	[1]
	4	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15,15; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 01	193 Secs (193 Secs) [==>]	[1]
	5	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15,15; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 01	193 Secs (193 Secs) [==>]	[1]
	6	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15,15; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 01	193 Secs (193 Secs) [==>]	[1]



Proposal 17289 - Visit 02 - Macroscopic Debris from the DART impact

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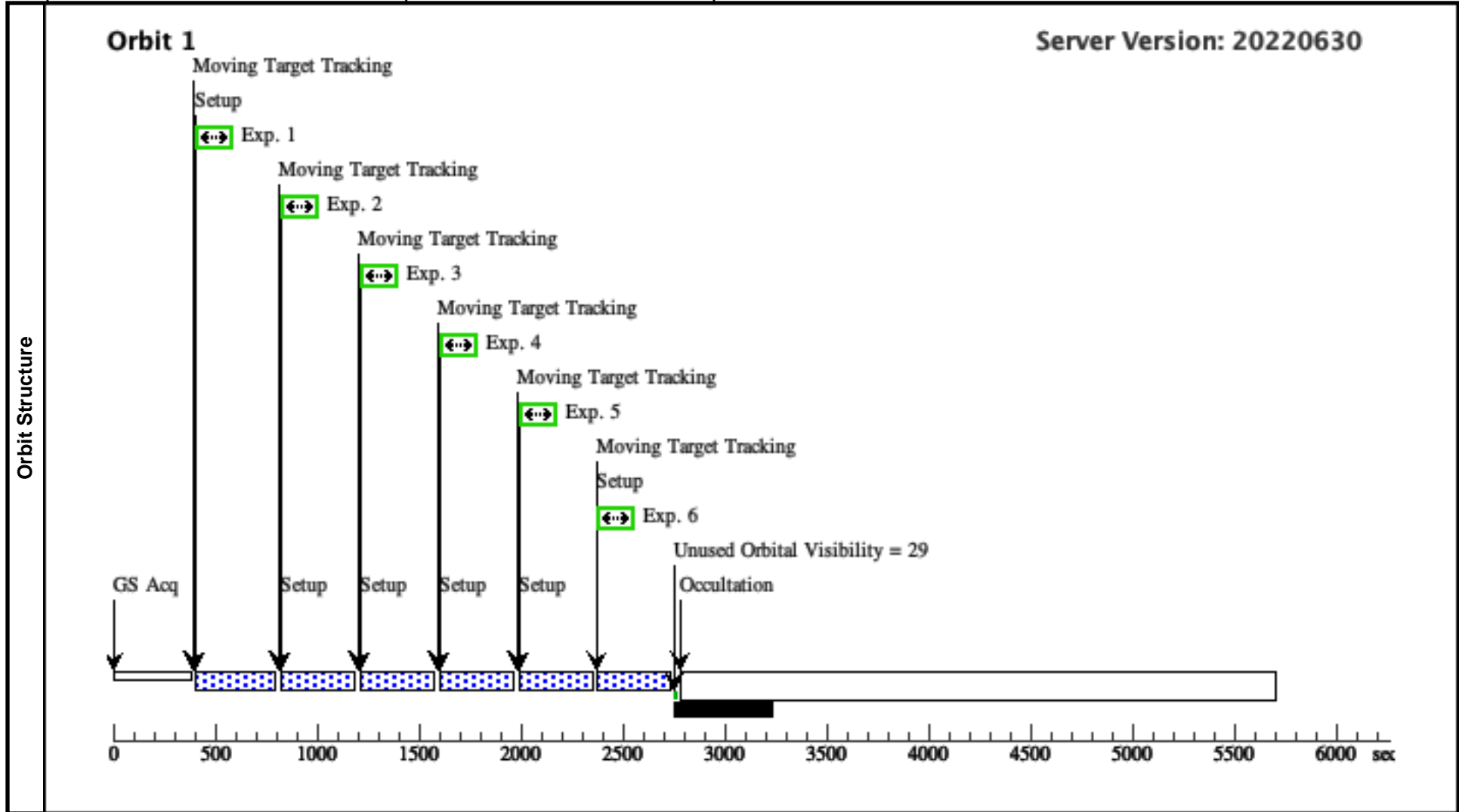
<b>Visit</b>	<b>Proposal 17289, Visit 02, implementation</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	<b>Diagnostics</b>	(Exposure 1 (Sequence 1-6 Non-Int in Visit 02)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser								
(Exposure 2 (Sequence 1-6 Non-Int in Visit 02)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 3 (Sequence 1-6 Non-Int in Visit 02)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 4 (Sequence 1-6 Non-Int in Visit 02)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 5 (Sequence 1-6 Non-Int in Visit 02)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 6 (Sequence 1-6 Non-Int in Visit 02)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	DIDYMOS	TYPE=ASTEROID,A=1.64340118643 9353,E=0.3836403201185644,I=3.413 079835162661 .O=73.0031688833396,W=319.550049 5128057,M=1.263702528507169,EQU INOX=J2000,EPOCH=24-OCT- 2022:12:00:00,EpochTimeScale=TDB, R0=1. .A1=0.,A2=-1.101805196413E- 14,A3=0. .ALN=1.,NM=2.,NN=0.,NK=0.,AMR AT=0.					EARTH		
Comments: Description=Binary asteroid (65803) Didymos Extended=NO										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.4,15. 4	Sequence 1-6 Non-Int in Visit 02	193 Secs (193 Secs) [==>]	[1]
	2	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.4,15. 4; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 02	193 Secs (193 Secs) [==>]	[1]
	3	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.4,15. 4; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 02	193 Secs (193 Secs) [==>]	[1]
	4	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.4,15. 4; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 02	193 Secs (193 Secs) [==>]	[1]
	5	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.4,15. 4; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 02	193 Secs (193 Secs) [==>]	[1]
	6	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.4,15. 4; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 02	193 Secs (193 Secs) [==>]	[1]



Proposal 17289 - Visit 03 - Macroscopic Debris from the DART impact

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<b>Visit</b>	<b>Proposal 17289, Visit 03, implementation</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Exposure 1 (Sequence 1-6 Non-Int in Visit 03)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser (Exposure 2 (Sequence 1-6 Non-Int in Visit 03)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser (Exposure 3 (Sequence 1-6 Non-Int in Visit 03)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser (Exposure 4 (Sequence 1-6 Non-Int in Visit 03)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser (Exposure 5 (Sequence 1-6 Non-Int in Visit 03)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser (Exposure 6 (Sequence 1-6 Non-Int in Visit 03)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser									
<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>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	DIDYMOS	TYPE=ASTEROID,A=1.64340118643 9353,E=0.3836403201185644,I=3.413 079835162661 .O=73.0031688833396,W=319.550049 5128057,M=1.263702528507169,EQU INOX=J2000,EPOCH=24-OCT- 2022:12:00:00,EpochTimeScale=TDB, R0=1. .A1=0.,A2=-1.101805196413E- 14,A3=0. .ALN=1.,NM=2.,NN=0.,NK=0.,AMR AT=0.					EARTH		
Comments: Description=Binary asteroid (65803) Didymos Extended=NO										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.8,15.8	Sequence 1-6 Non-Int in Visit 03	193 Secs (193 Secs) [==>]	[1]
	2	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.8,15.8; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 03	193 Secs (193 Secs) [==>]	[1]
	3	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.8,15.8; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 03	193 Secs (193 Secs) [==>]	[1]
	4	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.8,15.8; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 03	193 Secs (193 Secs) [==>]	[1]
	5	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.8,15.8; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 03	193 Secs (193 Secs) [==>]	[1]
	6	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 15.8,15.8; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 03	193 Secs (193 Secs) [==>]	[1]



Proposal 17289 - Visit 04 - Macroscopic Debris from the DART impact

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<b>Visit</b>	<b>Proposal 17289, Visit 04, implementation</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	<b>Diagnostics</b>	(Exposure 1 (Sequence 1-6 Non-Int in Visit 04)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser								
(Exposure 2 (Sequence 1-6 Non-Int in Visit 04)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 3 (Sequence 1-6 Non-Int in Visit 04)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 4 (Sequence 1-6 Non-Int in Visit 04)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 5 (Sequence 1-6 Non-Int in Visit 04)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
(Exposure 6 (Sequence 1-6 Non-Int in Visit 04)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	DIDYMOS	TYPE=ASTEROID,A=1.64340118643 9353,E=0.3836403201185644,I=3.413 079835162661 .O=73.0031688833396,W=319.550049 5128057,M=1.263702528507169,EQU INOX=J2000,EPOCH=24-OCT- 2022:12:00:00,EpochTimeScale=TDB, R0=1. .A1=0.,A2=-1.101805196413E- 14,A3=0. .ALN=1.,NM=2.,NN=0.,NK=0.,AMR AT=0.					EARTH		
Comments: Description=Binary asteroid (65803) Didymos Extended=NO										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 16.2,16.2	Sequence 1-6 Non-Int in Visit 04	193 Secs (193 Secs) [==>]	[1]
	2	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 16.2,16.2; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 04	193 Secs (193 Secs) [==>]	[1]
	3	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 16.2,16.2; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 04	193 Secs (193 Secs) [==>]	[1]
	4	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 16.2,16.2; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 04	193 Secs (193 Secs) [==>]	[1]
	5	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 16.2,16.2; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 04	193 Secs (193 Secs) [==>]	[1]
	6	(1) DIDYMOS	(1) DIDYMOS	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		POS TARG 16.2,16.2; NEW ALIGNMENT	Sequence 1-6 Non-Int in Visit 04	193 Secs (193 Secs) [==>]	[1]

