17795 - Active, but at What Cost? Determining Temporary Jupiter Co-orbital Comet P/2023 V6's Size and Probing The Gateway Region

Cycle: 32, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Dr. John W Noonan (PI) (Contact)	**Auburn University**
Dr. Theodore Richard Kareta (CoI) (CoPI) (Contact)	Lowell Observatory

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) P2023-V6-JPLV6	WFC3/UVIS	2	13-Nov-2024 11:00:15.0	yes

2 Total Orbits Used

ABSTRACT

The discovery of the transient Jupiter co-orbital comet P/2019 LD2 (ATLAS) drew significant interest. Not only will LD2 transition between being a Centaur and a Jupiter Family Comet (JFC) in 2063, the first time this process can be observed as it happens, it is also very active for its large heliocentric distance. We propose HST WFC3 observations of the newly discovered transient Jupiter co-orbital comet P/2023 V6 (PANSTARRS), the second such object known. Despite similar modern orbits, V6 is significantly (15x) less active than LD2 and most JFCs as determined via dust production measurements at the same heliocentric distance. As such, this suggests a correspondinly smaller nucleus size. If the nuclei are similar in size, we interpret these differences in activity as evolutionary, with V6 having lost a significant fraction of its near-surface ice compared to LD2 by previously being warmer. We will observe P/2023 V6 witht F350LP filter for two orbits of HST (a total of 2000s of exposure) to measure the nucleus size using HST's stable PSF and separate the weak dust coma from the nuclear contribution. If our hypothesis about V6's size is proven, this would be more evidence that LD2 is a pristine and ice-rich object, and thus it may display very strong activity when it becomes a JFC. We will use our

observattion to delineate the differences between V6 and LD2 to discuss the interpretation of cometary activity at large heliocentric distances. This has significant repercussions for our understanding of the end state of JFCs, as well as the small end of the cratering record of the Galilean Satellites.

OBSERVING DESCRIPTION

We will execute a short and highly impactful campaign to image the inner coma of P/2023 V6 (PANSTARRS) with WFC3 on the Hubble Space Telescope. The primary objective is to measure or constrain the size of this comet so as to contextualize the strength of its activity.To do so we will obtain 4 370s exposures of the F350LP filter per orbit for two consecutive orbits, for 8 total exposures, to reach a limiting magnitude of V=28 in ~2960s. The only relevant size scale to compare to V6 is the nuclear radius upper estimate from Kareta et al., 2021 of LD2, r< 1.2 km. V6 is a relatively condensed comet whose coma was about ~5 arcseconds across in November 2023. The spatial distribution of reflected light from V6's nucleus and coma will be compared against models of the WFC3 350LP PSF (e.g., with the software TinyTim (Krist, Hook, and Stoehr 2011) so as to understand the likely size of the object's nucleus. In the following paragraphs, we outline our sensitivity requirements, the proposed observations high scientific utility in the event of a non-detection, and our observing strategy.

At the distance of ~5 AU during our observational window (within a month of opposition of on January 4, 2025) this corresponds to a 5-sigma detection of a 100-m nucleus, approximately three times smaller than the smallest expected size of V6. Using the exposure time calculator for WFC3, we are able to obtain an SNR~10 detection of an LD2-sized nucleus (V~23) in just 44.7s on target in a 0.3"-radius circular aperture. If LD2 and V6 have the same activity strength, and thus V6 is approximately 4x smaller, then 1794.6s on target is sufficient. A non-detection of the nucleus at this level would be striking; it would indicate that V6 is far smaller than expected and yet still active out at Jupiter's orbit. This finding would have massive implications for the size frequency and compositions of the Galilean impactor population. With our 2-orbit allocation we are able to obtain nearly 3000s of exposure time, more than enough to accomplish our science goals.

To mitigate cosmic ray effects and other artifacts and improve sampling of the PSF we will dither each exposure (Dither pattern WFC3-UVIS-DITHER-LINE), placing V6 on the UVIS2-2K2C subarray. We will use a combination of Tiny Tim and DOLPHOT (Dolphin 2000, Dolphin 2016\footnote{http://americano.dolphinsim.com/dolphot/}) to model the PSF, which is not explicitly recommended by the WFC3 Instrument handbook (see 6.11.4). However, the F350LP filter does not have a publicly available PSF on the WFC3 PSF website. We also expect background dust coma contribution of V6 to substantially weaker than nucleus reflectance at the high angular resolution of HST WFC3, and as such do not expect substantial effort to be made to correct for dust distributions.

1-Observation Plan

We will use the WFC3-UVIS-DITHER-LINE Pattern for a single, 2-orbit visit, with four dithers per orbit. Each dither will be a 370s exposure, for a total of 1480s per orbit and 2960 s cumulatively.

2-Observing Constraints

The current observational arc for V6 is relatively short, leading to 3-sigma uncertainties of ~200" in right ascension and ~18" in declination near opposition in January 2025. We want to execute our visit within 30 days of opposition, between December 4, 2024 and February 4, 2025. We will maintain our own cadence of ground-based observations throughout 2024 to increase the arc length, submit astrometry to improve the orbital solution on Horizons, and narrow the positional uncertainties prior to execution of Cycle 32 orbits. These updates will be submitted as updated targets in the APT. However, given the 160" FOV of WFC3 we anticipate that the ephemeris uncertainties will be will within the FOV with only a few additional arc measurements in the fall of 2024.

Visit

Proposal 17795, Visit 01, implementation Wed Nov 13 16:00:15 GMT 2024

Diagnostic Status: Informational

Scientific Instruments: WFC3/UVIS

Special Requirements: GYRO MODE 1G; BETWEEN 04-DEC-2024:00:00:00 AND 04-FEB-2025:00:00:00

Diagnostics

(Visit 01) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=4 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1)

Solar System Targets

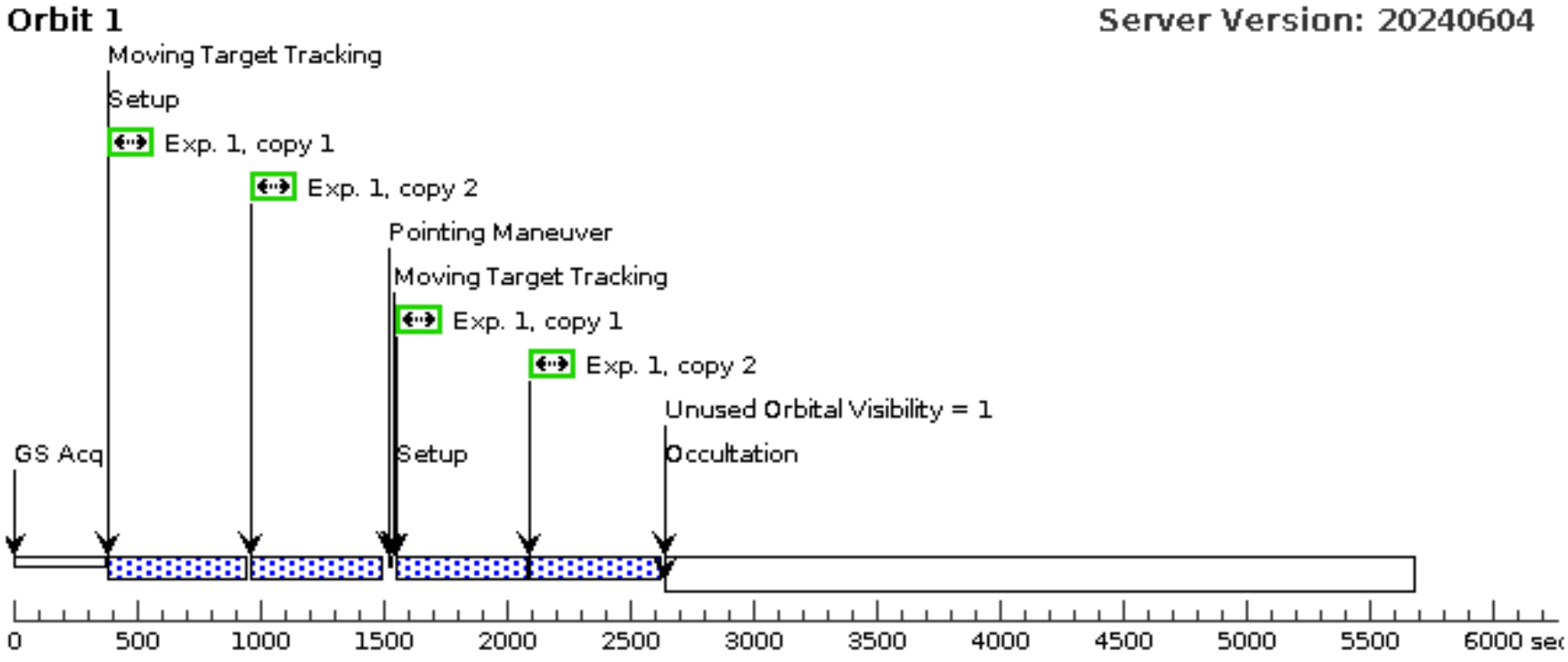
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	P2023-V6-JPLV6	TYPE=COMET,Q=4.383193965570757,E=0.1806836940613261,I=3.974862309687347,O=190.0079195419479,W=194.4890868749891,T=22-DEC-2022:23:19:23,TTimeScale=TDB,EQUINOX=J2000,EPOCH=03-DEC-2023:00:00:00,EpochTimeScale=TDB				EARTH

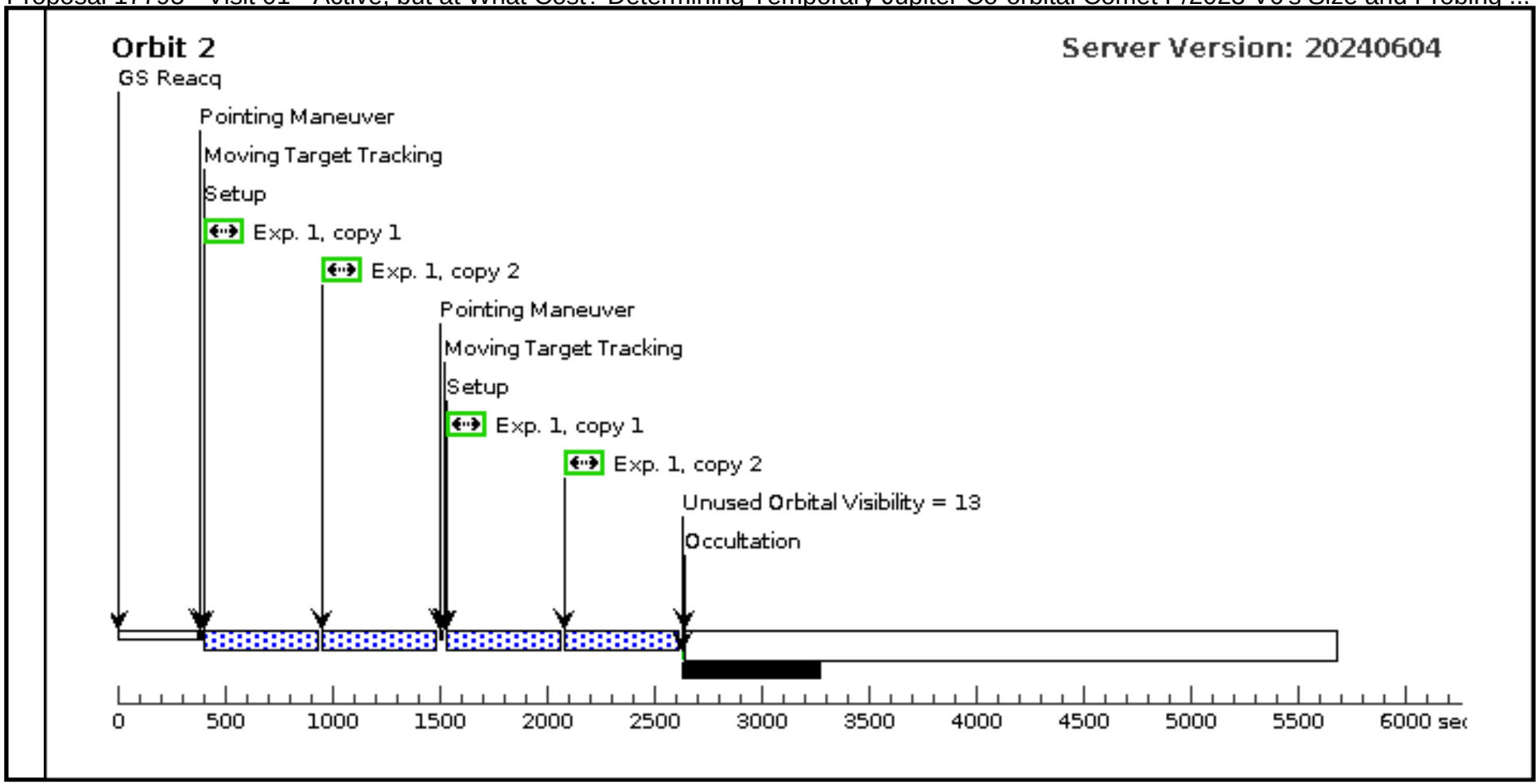
Comments: Description=Active Jupiter co-orbital object P/2023 V6

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	2023 V6	(1) P2023-V6-JPLV6	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP			Pattern 1, Exps 1-1 in Visit 01 (1)	370 Secs X 2 (2960 Secs)	
								[==>(Pattern 1, Copy 1)] *[==>(Pattern 1, Copy 2)]* *[==>(Pattern 2, Copy 1)]* *[==>(Pattern 2, Copy 2)]*	***[1]***
								[==>(Pattern 3, Copy 1)] *[==>(Pattern 3, Copy 2)]* *[==>(Pattern 4, Copy 1)]* *[==>(Pattern 4, Copy 2)]*	***[2]***

Orbit Structure




Orbit 2
Server Version: 20240604
GS Reacq
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 1, copy 1
Exp. 1, copy 2
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 1, copy 1
Exp. 1, copy 2
Unused Orbital Visibility = 13
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec