



18094 - Fireworks at the Gate: HST Observations of the Next Active Object in the JFC Transition Region

Cycle: 33, Proposal Category: GO

(Roman Preparatory Science)

(Availability Mode: SUPPORTED)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Dr. John W Noonan (PI) (Contact)	Auburn University
Dr. Theodore Richard Kareta (CoI) (CoPI)	Villanova University

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) GATEWAYOBJ	WFC3/UVIS	4	11-Aug-2025 20:00:32.0	yes

4 Total Orbits Used

ABSTRACT

The last six years have seen the discovery of three active objects in relatively circular orbits near Jupiter: P/2019 LD2, P/2020 MK4, and P/2023 V6. Each of these objects was discovered near their closest approach to the Sun, but the similarities end there. LD2 has remained strongly active since discovery, MK4 ceased activity and may have fragmented, and V6 hasn't been seen by ground-based observatories since October of 2024 implying it has dimmed by at least seven magnitudes. The varied behaviors of these objects indicates that their orbits within the "Gateway", where Centaurs become Jupiter Family Comets (JFCs) and vice versa, may not be a particularly peaceful zone. Given that these objects are the direct precursors of the JFCs, we need to understand their ongoing evolution better if we want to understand how the JFCs have been processed since their formation. We propose a four orbit non-disruptive Target of Opportunity carryover observation to observe the next object discovered to be active within the Gateway to constrain the source and physical properties of the activity and measure the size of the nucleus, or any fragments, directly. Only HST has

the sensitivity and resolution to detect these active nuclei and thus place constraints on just how active objects in the Gateway can be.

OBSERVING DESCRIPTION

We will execute a short and highly impactful campaign to image the inner coma of the next detected active object in the Gateway region 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 375s exposures of the F350LP filter per orbit for four consecutive orbits, for 8 total exposures, to reach a limiting magnitude of $V=28.5$ in ~ 6000 s. The only relevant size scale to compare to is the nuclear radius upper estimate from Kareta et al., 2021 of LD2, $r < 1.2$ km. The spatial distribution of reflected light from our target'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. Depending on the actual brightness of the object we may reduce the integration time for each exposure and add an additional exposure to maintain total integration time without risking saturation, (i.e. 5x300s, or 6x250s, etc.).

At a distance of ~ 5 AU from the Earth, this corresponds to a 7-sigma detection of a 100-m nucleus. Using the exposure time calculator for WFC3, we are able to obtain an $SNR \sim 10$ detection of an LD2-sized nucleus ($V \sim 23$) in just 44.7s on target in a 0.3"-radius circular aperture. If our target is found to have the same activity strength as LD2, and we plan for a range of nuclei, then 6000s on target is sufficient. A non-detection of the nucleus at this level would be striking; it would indicate that our target's nucleus is far smaller than expected and yet was active out beyond Jupiter's orbit. This finding would have massive implications for the size frequency and compositions of the Galilean impactor population and the debris in the region. With our 4-orbit allocation we are able to obtain 6000s 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 our target on the UVIS2-2K2C subarray. We will use a combination of Tiny Tim and DOLPHOT (Dolphin 2000, Dolphin 2016, <http://americano.dolphinim.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 from our target to be 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, 4-orbit visit, with four dithers per orbit. Each dither will be a 375s exposure, for a

total of 1500s per orbit and 6000 s cumulatively.

2-Observing Constraints

The observational arc for the next active Centaur detection may be relatively short, leading to large 3-sigma uncertainties in right ascension and declination. We want to execute our visit within 30 days of activity initiation during our Cycle 33 and 34 carryover ToO. We will maintain our own cadence of ground-based observations after detection to increase the arc length, submit astrometry to improve the orbital solution on Horizons, and narrow the positional uncertainties prior to execution of any 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 within the FOV with only a few additional arc measurements. We will confirm target availability in the Phase 2 APT via the visit planner prior to officially triggering the ToO.

Proposal 18094 - Visit 01 - Fireworks at the Gate: HST Observations of the Next Active Object in the JFC Transition Region

Tue Aug 12 00:00:33 GMT 2025

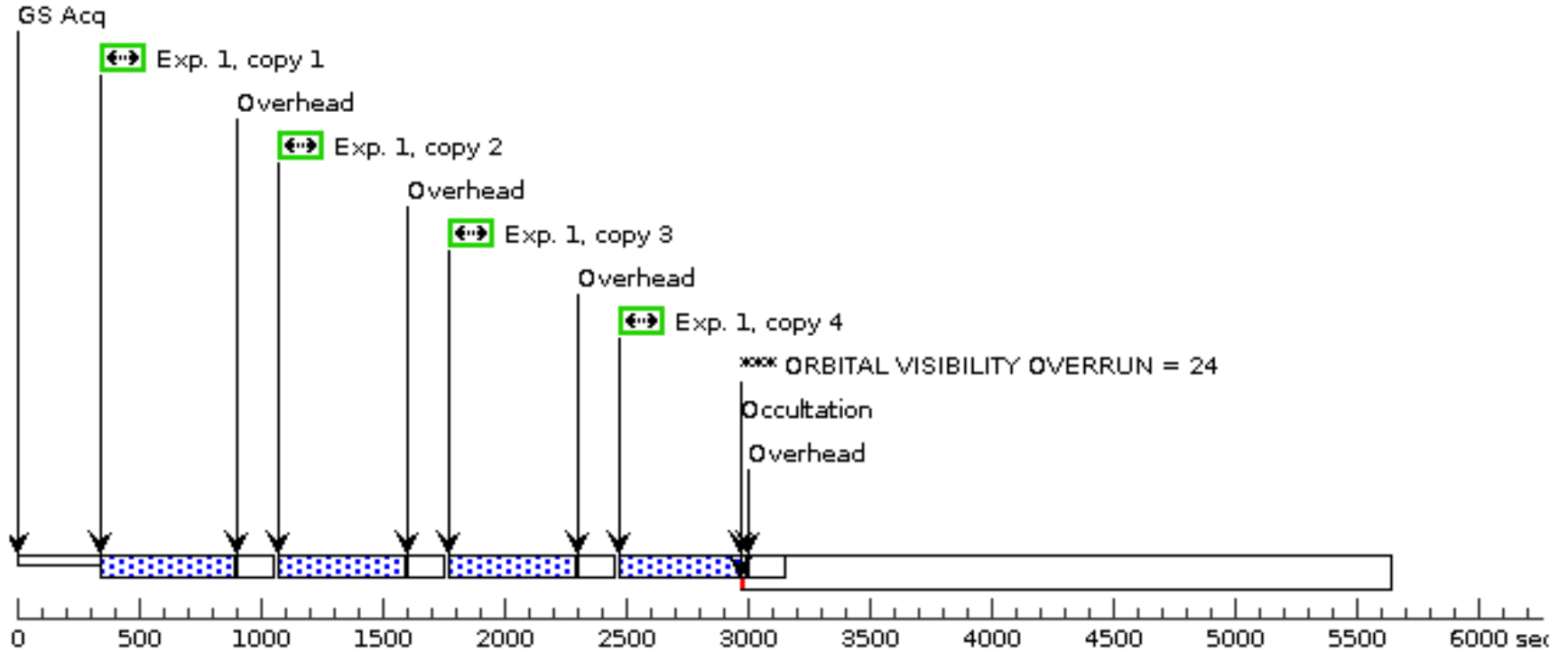
Visit	Proposal 18094, Visit 01 Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: ON HOLD ; TOO RESPONSE TIME 30.0D <i>On Hold Comments: We will trigger our observations on the discovery of an active object at or near the orbit of Jupiter with a magnitude upon discovery of $V < 23$, and request that our observations be carried out within 30 days of activation.</i>										
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Generic Targets											

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#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
Exposures	GatewayOB J	(1) GATEWAYOBJ	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP			Pattern 1, Exps 1-1 i n Visit 01 (1)	375 Secs X 4 (8276 Secs)	
								[==>521.0 Secs (Pattern 1, Copy 1)]	[1]
								[==>521.0 Secs (Pattern 1, Copy 2)]	
								[==>521.0 Secs (Pattern 1, Copy 3)]	
								[==>521.0 Secs (Pattern 1, Copy 4)]	
								[==>516.0 Secs (Pattern 2, Copy 1)]	[2]
								[==>516.0 Secs (Pattern 2, Copy 2)]	
								[==>516.0 Secs (Pattern 2, Copy 3)]	
								[==>516.0 Secs (Pattern 2, Copy 4)]	
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								[==>516.0 Secs (Pattern 3, Copy 2)]	
								[==>516.0 Secs (Pattern 3, Copy 3)]	
								[==>516.0 Secs (Pattern 3, Copy 4)]	
								[==>516.0 Secs (Pattern 4, Copy 1)]	[4]
								[==>516.0 Secs (Pattern 4, Copy 2)]	
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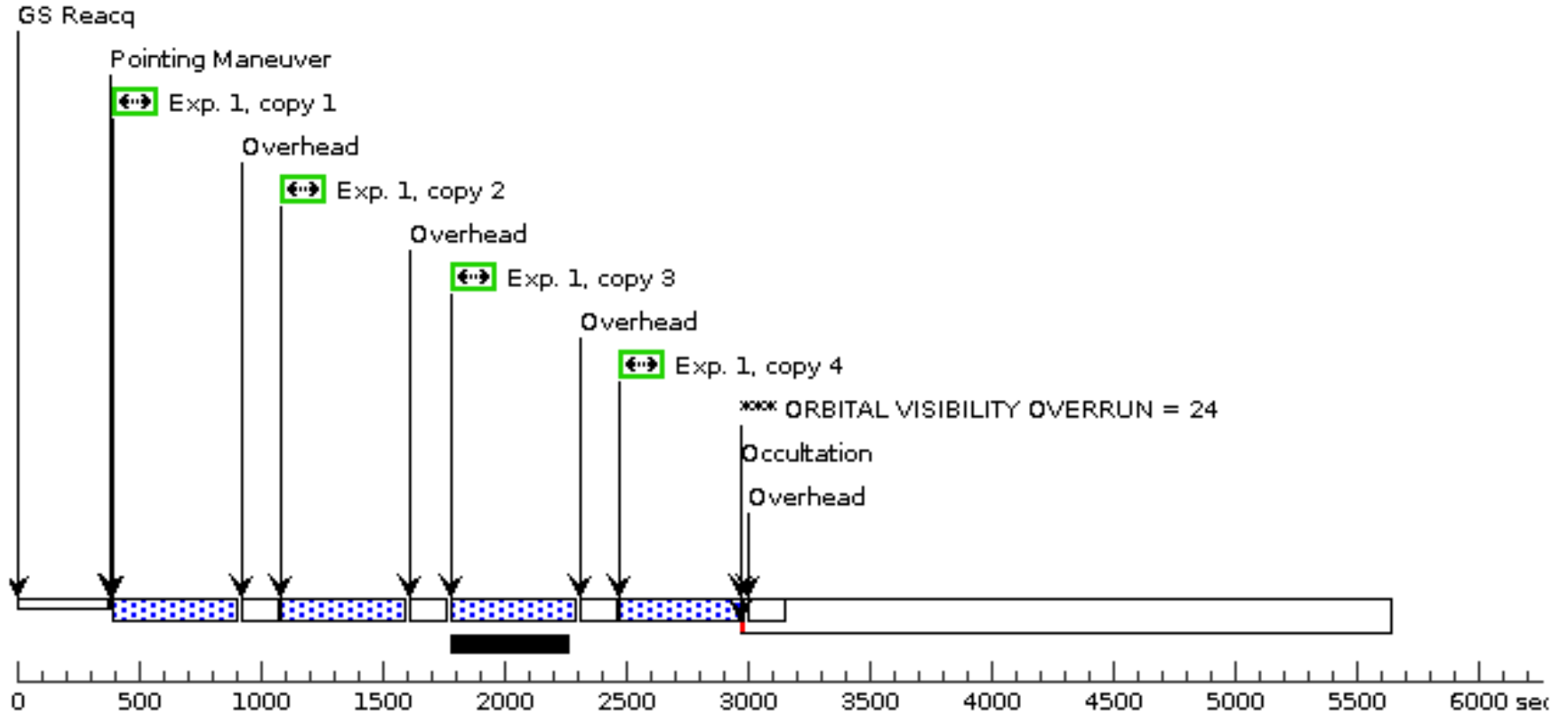
Orbit Structure

Orbit 1



Orbit 2

Server Version: 20250624



Orbit 3

