14693 - Testing the Torus Origin of the Broad Absorption Line Outflow in WPVS 007

Cycle: 24, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) 2MASX-J00391586-5117013	COS/FUV COS/NUV	2	29-Jul-2016 14:53:34.0	yes
02	(1) 2MASX-J00391586-5117013	COS/FUV COS/NUV	2	29-Jul-2016 14:53:36.0	yes

4 Total Orbits Used

ABSTRACT

A significant fraction of quasars exhibits blueshifted broad absorption lines in their rest-UV spectra, indicating powerful outflows emerging from the central engine. These outflows may remove angular momentum,

enrich the intergalactic medium, and contribute to feedback in galaxies. Despite years of study, the location and geometry of these outflows is not well constrained. Distance estimates range from the vicinity of the accretion disk to kiloparsecs from the central engine. In addition, global covering fractions are assumed to be significant, but there is little direct support for that assumption.

WPVS 007 is a low-luminosity broad absorption line active galaxy that has shown dramatic variability. A long-term increase in reddening from ~2010 observed by Swift culminated in a 60-day occultation event in 2015. Four HST COS observations, including one during the occultation, found a correlated decrease in the outflow velocity. Leighly et al. (2015) showed that these results imply that both the reddening and the outflow originate in the torus.

A torus origin for BAL outflows is attractive because dust opacity may offer an acceleration mechanism. The model predicts continued correlation between the outflow velocity and the reddening. We propose two HST COS spectroscopic observations, one at the post-occultation intermediate reddening, and a ToO to be performed when the object reaches low reddening. The unusual variabililty may be observable in WPVS 007 on year timescales due to its small spatial and temporal scales. Observations of these transient effects may be key to understanding quasars in general and BALs in particular.

OBSERVING DESCRIPTION

We were awarded two observations of WPVS 007 using COS in the FUV channel with the G140L grating. We observed this object in March 30,

2015 in the same configuration, and we had previously observed it in 2010 and twice in 2013. We use the same observing strategy as in the 2015 observation.

The second of the two observations is a non-disruptive ToO. We describe the observational criteria for that observation below.

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PROPERTIES OF WPVS 007:

The reddening of our Galaxy in the direction of WPVS 007 is 0.012 mag. The redshift is z=0.02882. The GSC II states that the best optical magnitude is 13.6. This, however, is the integrated magnitude for the galaxy which is resolved at this redshift. Recent observations using Swift UVOT show that it has a V magnitude of almost 15.2. The object is variable, however; we have been monitoring it for more than 10 years using Swift, and those data reveal a magnitude range between 15 and 15.59. So we assign an uncertainty of 0.3 magnitude. The corresponding range over UVW2 (central wavelength 1928 Angstroms) is 14.13 to 15.5, for a conservative uncertainty of about 0.7.

The brightest line in the FUV is Lyalpha, and it will be present in the spectrum. Using an approximate spectral model based on the FOS spectrum of WPVS 007, but renormalizing it to the flux observed during the high-flux 2010 COS observation, we find that the brightest pixel (at Lyalpha) attains a count rate of only 0.78 counts/s (COS.sp.823895).

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OBSERVATION DETAILS:

The principal absorption lines of interest are Ly alpha, SiIV, and CIV. For this object, with z=0.02882, these lines lie slightly blueward of 1250, 1440, and 1595 Angstroms. Using CENWAVE=1105 will provide good throughput at these lines. We are also interested in PV absorption, which will lie blueward of 1155 Angstroms. This will be covered using CENWAVE=1105, but only for larger values of FP-POS=3 or 4.

ACQUISITION:

WPVS007 is in the GSC2 and therefore it has ICRS coordinates with positional uncertainties of 0.3 arc seconds in RA and 0.33 arcseconds in dec. These uncertainties are less than the nominal value of 0.4, and therefore we do not have to do a ACQ/SEARCH. Rather, we will start with an ACQ/IMAGE to acquire the object. This is the same method we used for the 2015 and 2013 observations.

To develop the acquisition strategy, we consider the range of fluxes that might possibly be present. The flux density of the object was ~1.0e-14 erg/s/cm^2/A during the 2010 COS observation; this marks the historical high flux state. In 2015, we observed WVPS 007, when it was in a low state, almost as low as it had been when observed by HST FOS in 1996. That spectrum has a flux density 2.5e-15 erg/s/cm^2/A in the vicinity of 1500 Angstroms observed frame. So we

consider a flux density range of 0.25-1.0e-14 erg/s/cm^2/A account for variability. The COS Instrument handbook Figure 8.4 indicates that we can use the PSA aperture and MIRRORB for this flux range, and as stated in Section 8.7.1, we need a S/N of 40. Using a heavily-smoothed version of the HST FOS spectrum, extended toward short wavelengths using a scaled FOS quasar composite (Zheng et al. 1991), we use the COS ETC to determine the exposure time, finding that 51 seconds will be adequate to produce the required S/N=40 (Table 8.3; COS.ta.668122) for the low-flux case, and 12 seconds for the high flux case. We are continually monitoring WPVS007, so it is unlikely we will observe it in the low-flux state. (Note that the ToO will be triggered when the object reaches a bright and unreddened state.). At the same time, the ETC does not suggest that there will be any saturation, etc. Therefore, we choose an exposure time of 50 seconds for the acquisition.

The APT BOT estimates that the object should be too bright for this acquisition. This is because the conservative assumptions made by the BOT are not appropriate for this target. First, it uses the magnitude given in the GSC2 of 13.6. That is the magnitude for the galaxy, which is resolved at this redshift, rather than the target, which has a magnitude closer to 15.6. Second, it assumes a OV star spectrum, whereas the object is a modestly reddened AGN. The continuum flux level is about 0.25--1.0e-14 erg/s/cm^2/A at 1500 Angstroms.

SCIENCE EXPOSURES:

All exposures are chosen to be in TIME-TAG mode and FLASH is set to Yes. We use a heavily smoothed version of the HST FOS spectrum (the

low state), extended to shorter wavelengths using the FOS quasar composite spectrum (Zheng et al. 1991), and scaled to a 4-times brighter spectrum, corresponding to the historical flux maximum in order to estimate the buffer time. The COS ETC estimates a buffer time of 3,386 seconds (COS.sp.823906) for the high-flux state. We conservatively choose a buffer time equal to 1000 seconds.

THE TWO VISITS:

We will observe the object twice. The goal is to examine the absorption line properties as the reddening decreases away from the 2015 occultation.

- The first observation is intended to catch the object in an intermediate-reddening state. In our model, we should observe prominent absorption lines with an intermediate maximum outflow velocity. This observation is unconstrained, but we plan to inform STScI that the Swift monitoring indicates that the reddening at the time of Phase II preparation has attained an intermediate value, and that it is falling, so observation sooner rather than later would be best for the science.

- The second observation is intended to catch the object in a low-reddening state. In our model, we should observe prominent absorption lines with high maximum outflow velocity. This observation is held until the non-disruptive ToO is triggered. The ToO will be triggered when the object has attained E(B-V) <= 0.16, based on the Swift photometry, and has maintained that low value for 3 months.

Visit

Proposal 14693, WPVS007 ACQ (01) Fri Jul 29 18:53:37 GMT 2016

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Diagnostics

(WPVS007 ACQ (01)) Warning (Form): If the target coordinates are not known to 0.4" (or better), an ACQ/SEARCH should precede the ACQ/IMAGE.

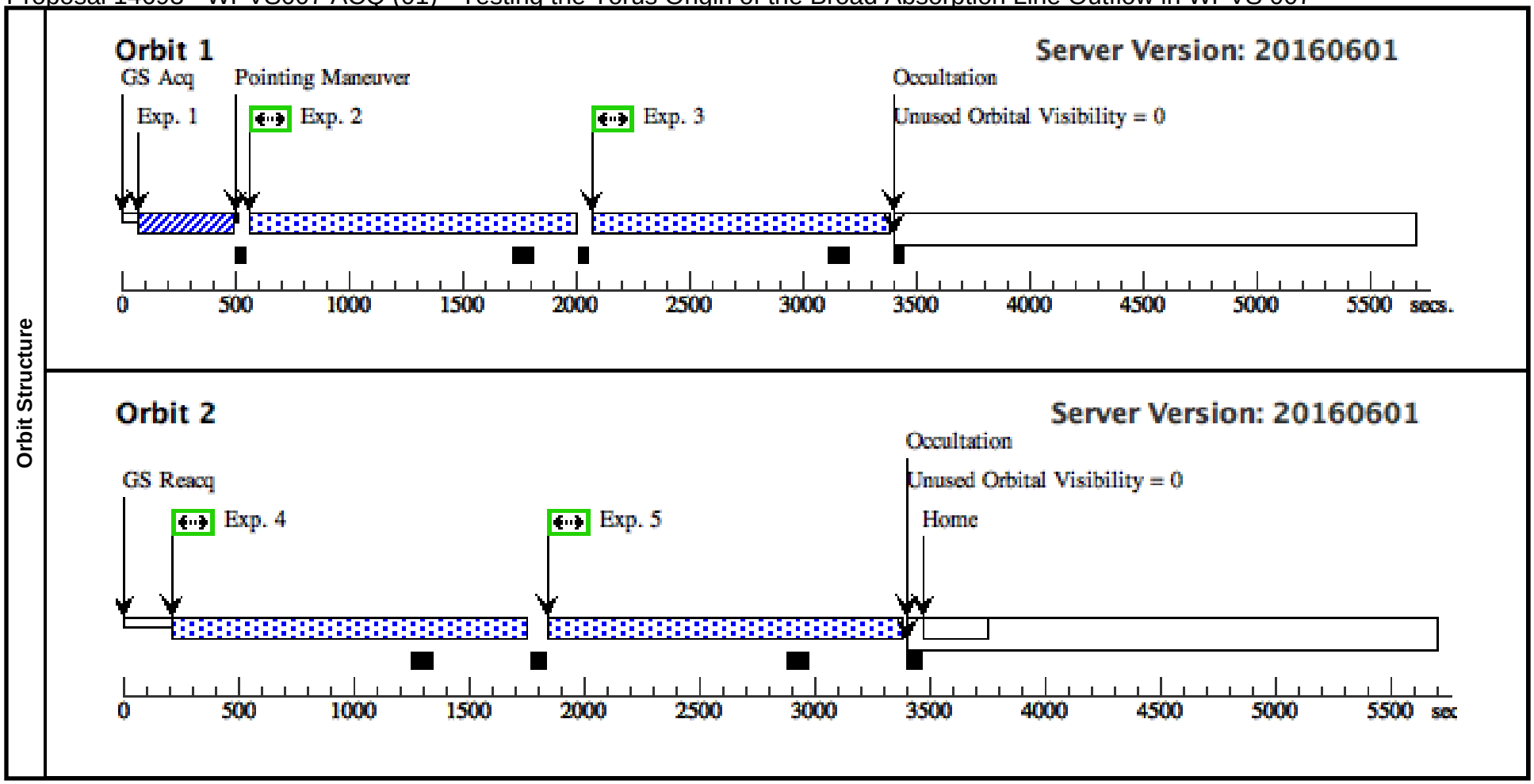
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	2MASX-J00391586-5117013 Alt Name1: WPVS007 Alt Name2: GSC1ID0803000885	RA: 00 39 15.8290 (9.8159542d) Dec: -51 17 1.41 (-51.28373d) Equinox: J2000	Proper Motion RA: 0.0 mas/yr Proper Motion Dec: 0.0 mas/yr Parallax: 0.0" Epoch of Position: 1993.69 Redshift: 0.2882	V=15.2+/-0.3 Swift UVOT W2 (cen. wave = 1928 Angstroms): 14.6 +/- 0.7	Reference Frame: ICRS

Comments: Magnitudes and variances based on > 10 years of Swift monitoring
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	WPVS007 ACQ (COS.ta.822202)	(1) 2MASX-J00391586-5117013	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				50 Secs (50 Secs) *[==>]*	***[1]***
2	(COS.sp.823895)	(1) 2MASX-J00391586-5117013	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; FLASH=YES; BUFFER-TIME=1000			1260.0 Secs (1260 Secs) *[==>]*	***[1]***
3	(COS.sp.823895)	(1) 2MASX-J00391586-5117013	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; FLASH=YES; BUFFER-TIME=1000.0			1260.0 Secs (1260 Secs) *[==>]*	***[1]***
4	(COS.sp..823895)	(1) 2MASX-J00391586-5117013	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; FLASH=YES; BUFFER-TIME=1000			1487.0 Secs (1487 Secs) *[==>]*	***[2]***
5	(COS.sp..823895)	(1) 2MASX-J00391586-5117013	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; FLASH=YES; BUFFER-TIME=1000			1487.0 Secs (1487 Secs) *[==>]*	***[2]***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Server Version: 20160601
GS Acq
Pointing Maneuver
Occultation
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Exp. 2
Exp. 3
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500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.
Orbit 2
Server Version: 20160601
Occultation
GS Reacq
Unused Orbital Visibility = 0
Exp. 4
Exp. 5
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 14693, WPVS007 ACQ (02) Fri Jul 29 18:53:37 GMT 2016

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: ON HOLD ; TOO RESPONSE TIME 22.0D

On Hold Comments: The second visit is a non-disruptive ToO with longterm status. The target is being continuously monitored by Swift, with observations approximately every two weeks. We are analyzing the Swift UVOT photometry to monitor the reddening. The ToO will be triggered when the reddening has decreased to E(B-V) <= 0.16, and has remained in that state for three months.

Diagnostics

(WPVS007 ACQ (02)) Warning (Form): If the target coordinates are not known to 0.4" (or better), an ACQ/SEARCH should precede the ACQ/IMAGE.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
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Comments: Magnitudes and variances based on > 10 years of Swift monitoring
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Exposures

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2	(COS.sp.823895)	(1) 2MASX-J00391586-5117013	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; FLASH=YES; BUFFER-TIME=1000.0			1260.0 Secs (1260 Secs) *[==>]*	***[1]***
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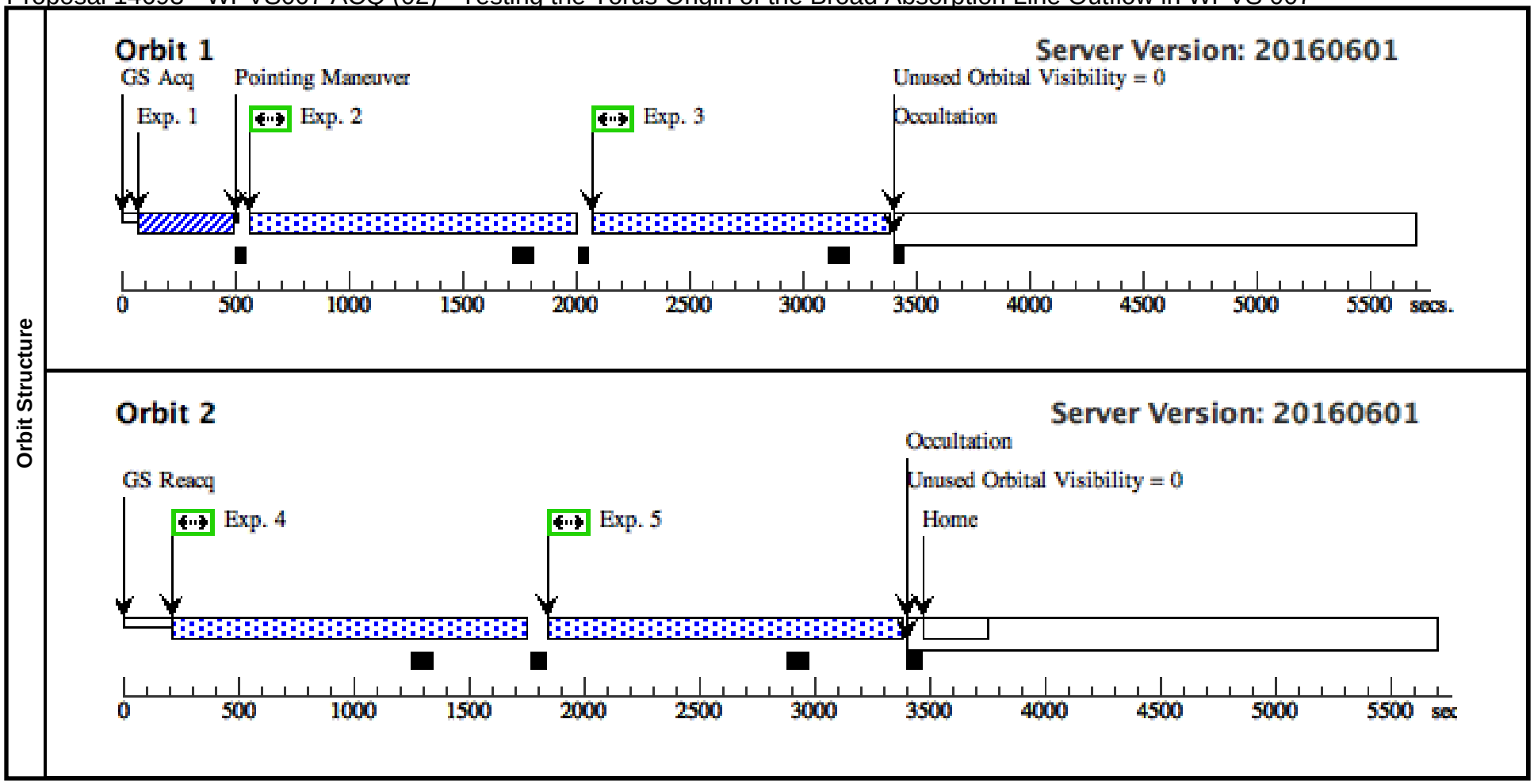
5	(COS.sp..823895)	(1) 2MASX-J00391586-5117013	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; FLASH=YES; BUFFER-TIME=1000.0			1487.0 Secs (1487 Secs) *[==>]*	***[2]***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Server Version: 20160601
GS Acq
Pointing Maneuver
Unused Orbital Visibility = 0
Exp. 1
Exp. 2
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.
Orbit 2
Server Version: 20160601
Occultation
GS Reacq
Unused Orbital Visibility = 0
Exp. 4
Exp. 5
Home
0
500
1000
1500
2000
2500
3000
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sec