15209 - High-Speed Bullet Ejections during the AGB to Planetary Nebula Transition: A Study of the Carbon Star V Hydrae

Cycle: 25, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Raghvendra Sahai (PI) (Contact)	**Jet Propulsion Laboratory**	**raghvendra.sahai@jpl.nasa.gov**
Dr. Mark R. Morris (CoI)	University of California - Los Angeles	morris@astro.ucla.edu
Ms. Samantha Scibelli (CoI)	State University of New York at Stony Brook	samanthascibelli@gmail.com
Prof. Chinnathambi Muthumariappan (CoI)	Indian Institute of Astrophysics	muthu@iiap.res.in

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) V-HYDRAE	STIS/CCD	4	14-Jul-2017 17:03:57.0	yes

4 Total Orbits Used

ABSTRACT

The carbon star V Hya is experiencing heavy mass loss as it undergoes the transition from an AGB star to a planetary nebula (PN). This is possibly the earliest object known in this brief phase, which is so short that few nearby stars are likely to be caught in the act. Molecular observations reveal that a bipolar nebula has been established even at this early stage.

Using STIS, we obtained high spatial-resolution long-slit optical spectra of V Hya spanning 3 epochs spaced apart by a year during each of two periods (2002-2004, 2011-2013). These data reveal

high-velocity emission in [SII] lines from compact blobs located both on- and off-source, with the ejection axis executing a flip-flop, both in, and perpendicular to, the sky-plane. We have proposed a detailed model in which V Hya ejects high-speed (200-250 km/s) bullets once every 8.5 yr associated with periastron passage of a binary companion in an eccentric orbit with an 8.5 yr period. We suggest that the jet driver is an accretion disk (produced by gravitational capture of material from the primary) that is warped and precessing. Our model predicts the locations of previously ejected bullets in V Hya and future epochs at which new bullets will emerge. We now propose new STIS observations of these remarkable bullet ejections over two new epochs well separated from previous ones, to robustly test our model. The proposed observations will provide us with an unprecedented opportunity to look on as V Hya's circumstellar envelope is sculpted by these bullets. Our study will help solve the long-standing puzzle of how the spherical mass-loss envelopes of AGB stars evolve into bipolar and multipolar PNe.

OBSERVING DESCRIPTION

We will utilise an observing set-up that uses a mosaic of 5 parallel slits aligned E-W to probe the spatio-kinematic structure of the emission-line blobs in the [SII]$\lambda\lambda\,4069.7,4077.5$ doublet. STIS will be used with G430M (tilt setting of 4194) and the $52{"}\times$0\farcs1 slit to obtain spectra in the $\lambda\lambda$4051-4337{\AA} range. From our previous data, the [SII]λ4066{\AA} line has a peak intensity that is about4$\times10^{-13}$ erg s^{-1} cm^{-2} {\AA}$^{-1}$ arcsec^{-2} and a FWHM of about 1\AA. We will use exposure times ($\sim$1100\,s per dither position), and CR-SPLIT=2, which gives us a S/N$\gsim$40--80 at the peak of the [SII]λ4066{\AA} line, and a S/N$\gsim$15 in the continuum (which is roughly a factor 4 weaker in the offset slit, where the high-velocity bullet emission is strongest). This high S/N ratio is necessary because it allows us to measure the spatial offset of the peak from the source continuum with sub-pixel accuracy, which is important since the proper motion is about 0\farcs07 per year (and may decrease with time). In addition, we want to continue to be able to detect important fainter lines ([FeII]λ4241 \& 4285{\AA}) which we have detected previously, and which provide additional probes of the physical conditions in the bullet. The G430M observations will require 4 orbits per epochs.

The available windows for observing V Hya given our STIS slit ORIENT constraints (we require an ORIENT within $\pm$4\arcdeg~of those used in the previous epochs) occur twice each calendar year, i.e., (1) in June/Aug, and (2) in

Dec.

Visit

Proposal 15209, Visit 01 Fri Jul 14 21:03:59 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; SCHED 30%; ORIENT 128.5D TO 136.5 D; ORIENT 308.5D TO 316.5 D

Patterns

#	Primary Pattern		Secondary Pattern		Exposures
(1)	Pattern Type=STIS-PERP-TO-SLIT	Coordinate Frame=POS-TARG	Pattern Type=STIS-ALONG-SLIT	Coordinate Frame=POS-TARG	(3)
	Purpose=MOSAIC	Pattern Orientation=0.0	Purpose=DITHER	Pattern Orientation=90.0	
	Number Of Points=5	Angle Between Sides=	Number Of Points=3	Angle Between Sides=	
	Point Spacing=0.1	Center Pattern=true	Point Spacing=0.22851	Center Pattern=false	
	Line Spacing=		Line Spacing=		

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-HYDRAE	RA: 10 51 37.2566 (162.9052358d)	Proper Motion RA: -11.02 mas/yr	V=6.8+/-2	Reference Frame: ICRS
		Dec: -21 15 0.32 (-21.25009d)	Proper Motion Dec: 2.29 mas/yr	B=12.7	
		Equinox: J2000	Epoch of Position: 2000		

Comments: Extended=YES

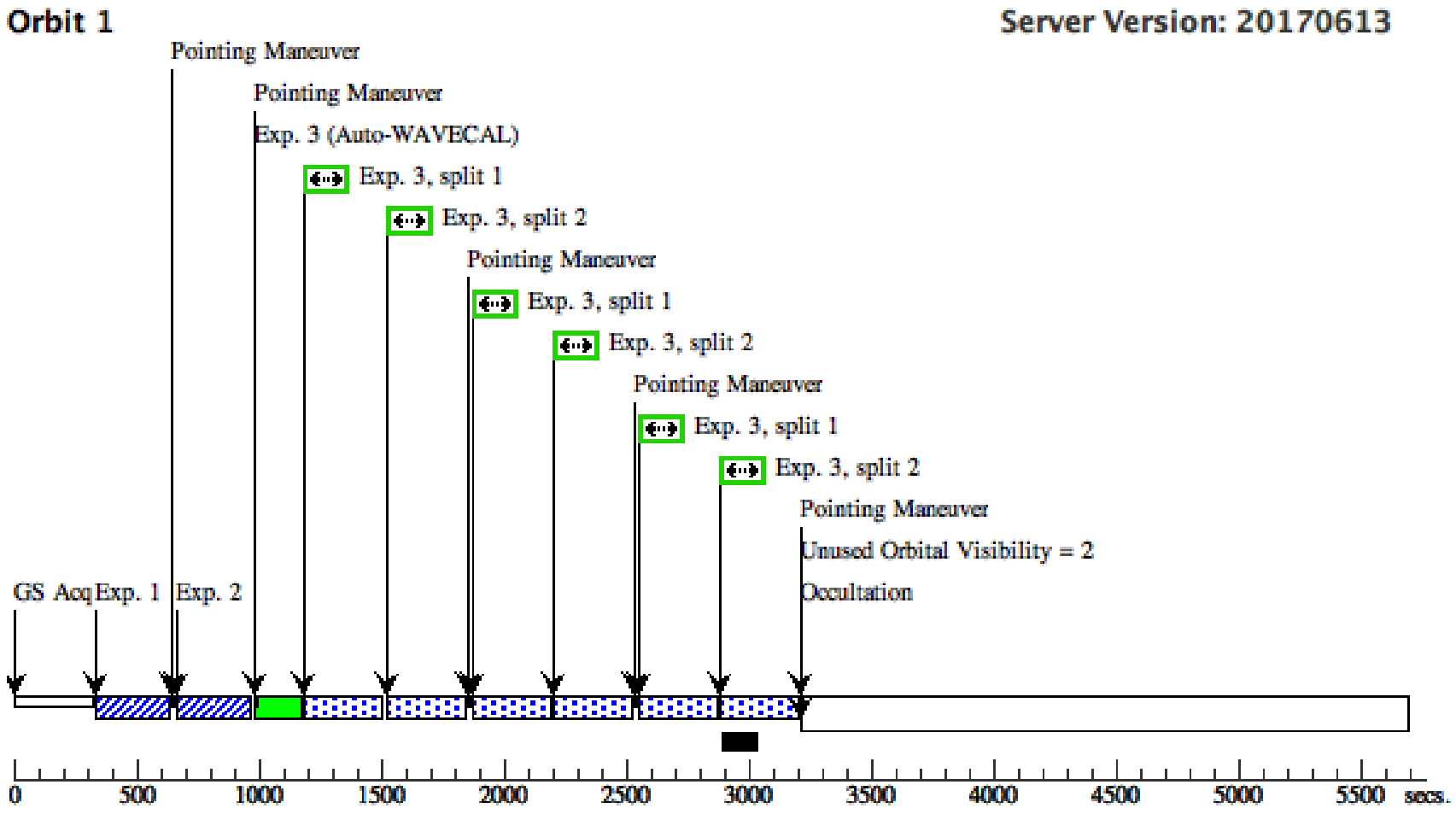
Exposures

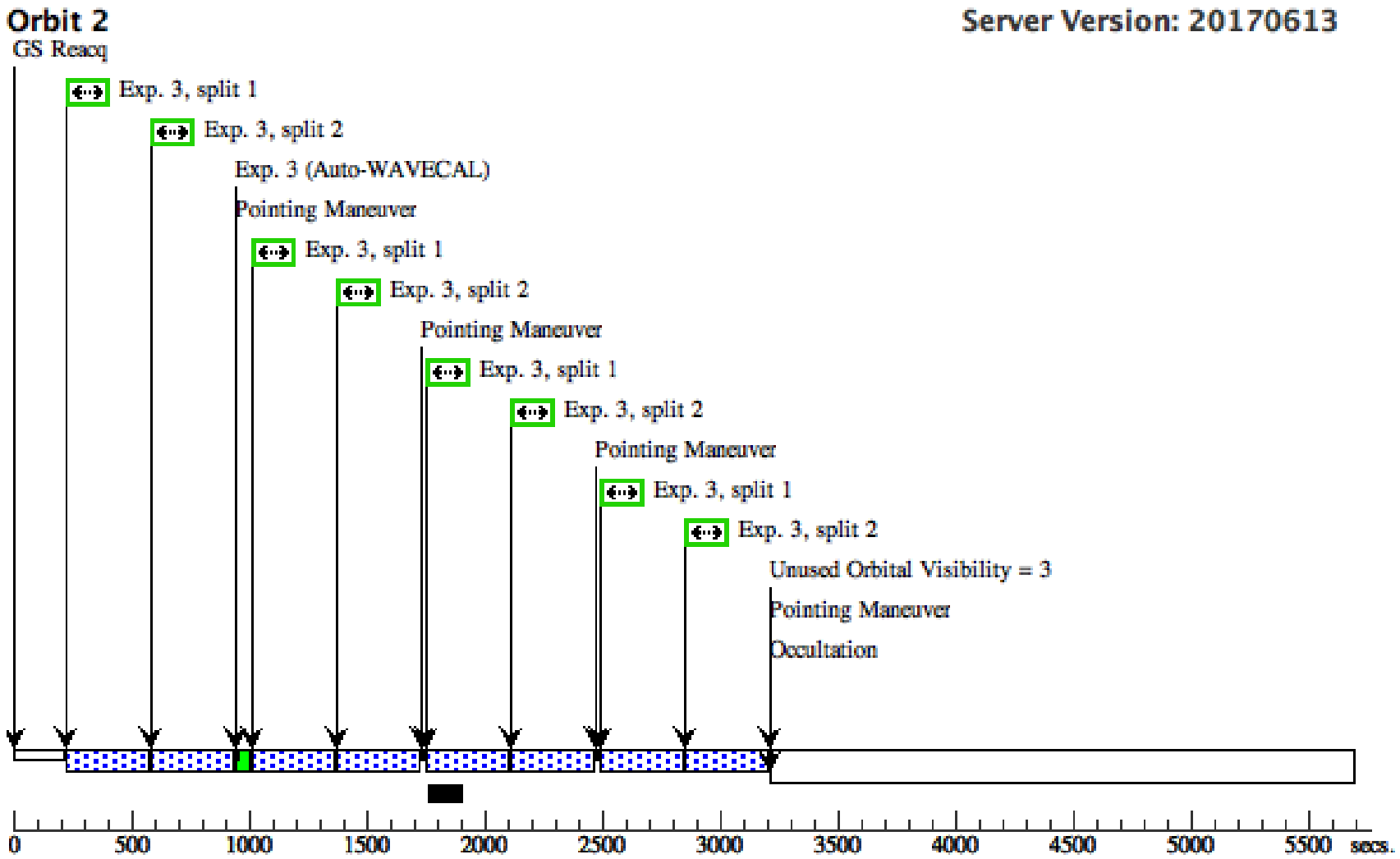
#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) V-HYDRAE	STIS/CCD, ACQ, F25ND3	MIRROR				1.3 Secs (1.3 Secs)	
								[==>]	***[1]***
2		(1) V-HYDRAE	STIS/CCD, ACQ/PEAK, 52X0.1	G750L				1.0 Secs (1 Secs)	
				7751 A				*[==>]*	
									[1]

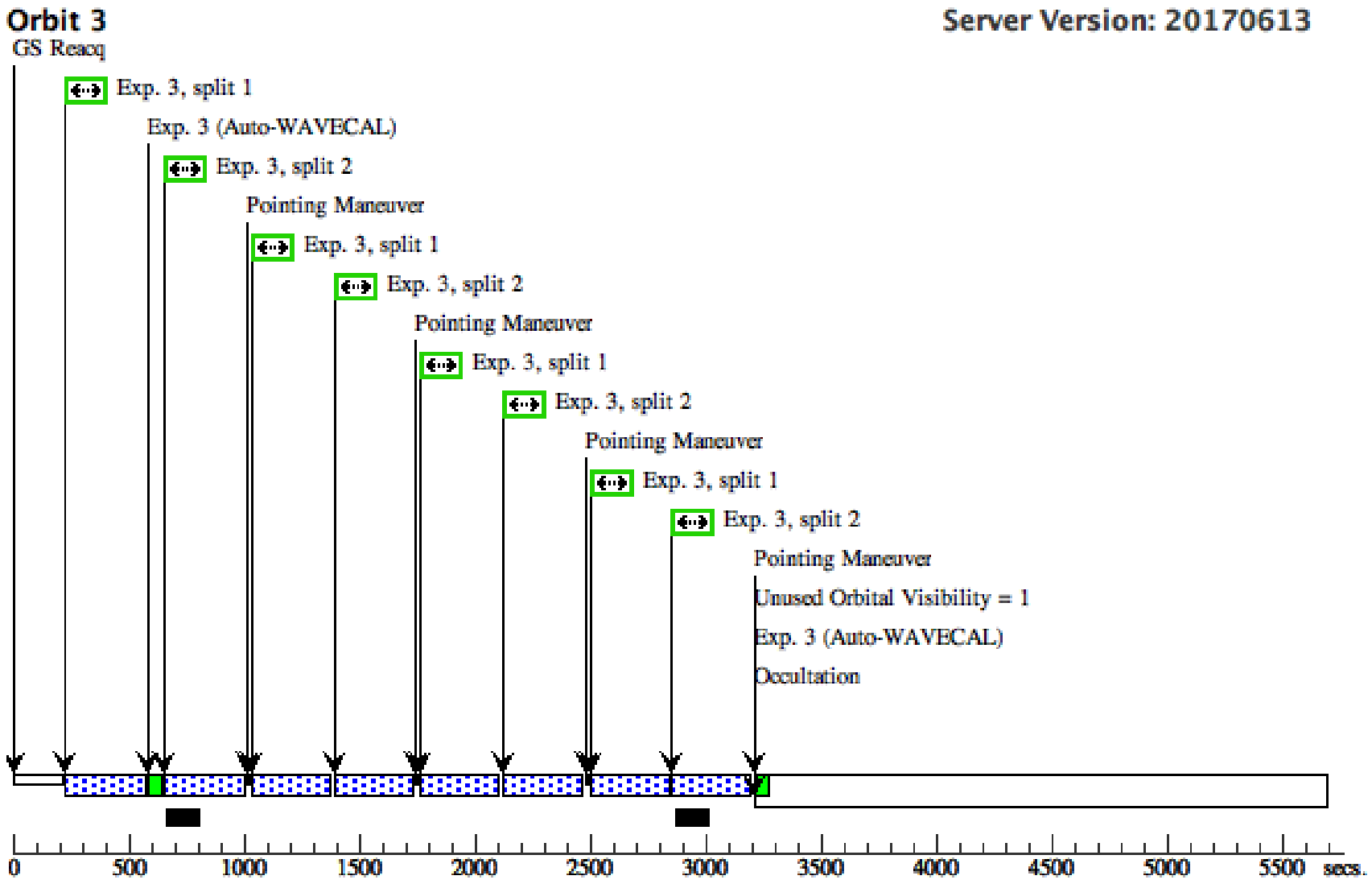
	3	(1) V-HYDRAE	STIS/CCD, ACCUM, 52X0.1	G430M 4194 A	Pattern 1, Exps 3-3 in Visit 01 (1)	560 Secs (9160 Secs)	
						[==>284.0 Secs (Pattern 1,1, Split 1)] *[==>284.0 Secs (Pattern 1,1, Split 2)]* *[==>284.0 Secs (Pattern 1,2, Split 1)]* *[==>284.0 Secs (Pattern 1,2, Split 2)]* *[==>284.0 Secs (Pattern 1,3, Split 1)]* *[==>284.0 Secs (Pattern 1,3, Split 2)]*	***[1]***
						[==>313.0 Secs (Pattern 2,1, Split 1)] *[==>313.0 Secs (Pattern 2,1, Split 2)]* *[==>313.0 Secs (Pattern 2,2, Split 1)]* *[==>313.0 Secs (Pattern 2,2, Split 2)]* *[==>313.0 Secs (Pattern 2,3, Split 1)]* *[==>313.0 Secs (Pattern 2,3, Split 2)]* *[==>313.0 Secs (Pattern 3,1, Split 1)]* *[==>313.0 Secs (Pattern 3,1, Split 2)]*	***[2]***
						[==>310.0 Secs (Pattern 3,2, Split 1)] *[==>310.0 Secs (Pattern 3,2, Split 2)]* *[==>310.0 Secs (Pattern 3,3, Split 1)]* *[==>310.0 Secs (Pattern 3,3, Split 2)]* *[==>310.0 Secs (Pattern 4,1, Split 1)]* *[==>310.0 Secs (Pattern 4,1, Split 2)]* *[==>310.0 Secs (Pattern 4,2, Split 1)]* *[==>310.0 Secs (Pattern 4,2, Split 2)]*	***[3]***

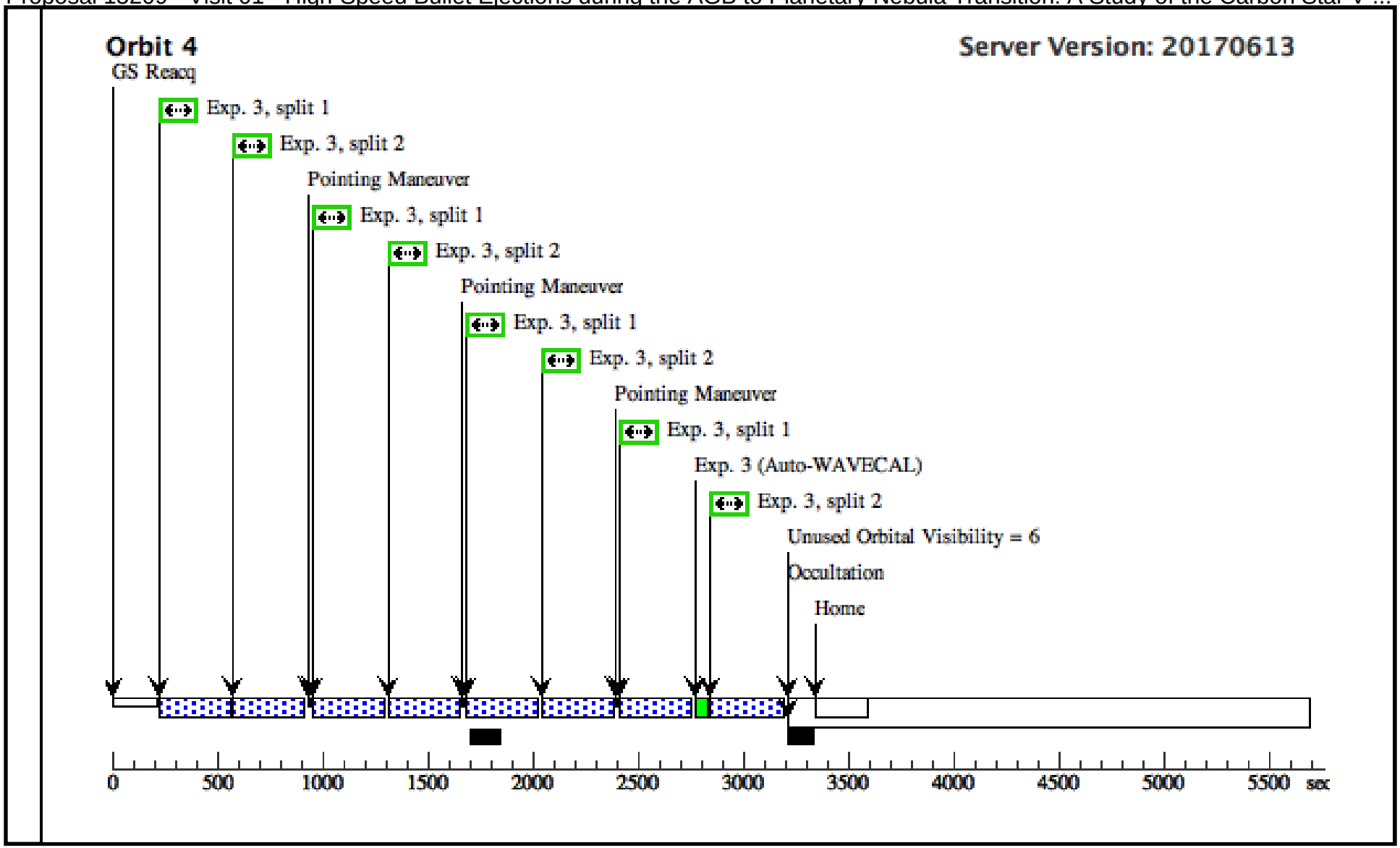
		[==>309.0 Secs (Pattern 4,3, Split 1)] *[==>309.0 Secs (Pattern 4,3, Split 2)]* *[==>309.0 Secs (Pattern 5,1, Split 1)]* *[==>309.0 Secs (Pattern 5,1, Split 2)]* *[==>309.0 Secs (Pattern 5,2, Split 1)]* *[==>309.0 Secs (Pattern 5,2, Split 2)]* *[==>309.0 Secs (Pattern 5,3, Split 1)]* *[==>309.0 Secs (Pattern 5,3, Split 2)]*	***[4]***
	Comments: 15 exposures to produce a mosaic of 5 slits, spaced apart by 0.1 arcsec, with a 3-point dither along the slit for each slit position		

Orbit Structure




Orbit 2
Server Version: 20170613
GS Reacq
Exp. 3, split 1
Exp. 3, split 2
Exp. 3 (Auto-WAVECAL)
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Unused Orbital Visibility = 3
Pointing Maneuver
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 3
Server Version: 20170613
GS Reacq
Exp. 3, split 1
Exp. 3 (Auto-WAVECAL)
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Unused Orbital Visibility = 1
Exp. 3 (Auto-WAVECAL)
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 4
Server Version: 20170613
GS Reacq
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3, split 2
Pointing Maneuver
Exp. 3, split 1
Exp. 3 (Auto-WAVECAL)
Exp. 3, split 2
Unused Orbital Visibility = 6
Occultation
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec