12227 - Tracking the Evolution of a Knotty, High-Speed Jet in the Carbon Star, V Hydrae

Cycle: 18, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Raghvendra Sahai (PI)	**Jet Propulsion Laboratory**	**raghvendra.sahai@jpl.nasa.gov**
Dr. Mark Morris (CoI)	University of California - Los Angeles	morris@astro.ucla.edu
Dr. Gillian R. Knapp (CoI)	Princeton University	gk@astro.princeton.edu
Dr. Cecilia Barnbaum (CoI)	Valdosta State University	cbarnbau@valdosta.edu

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) V-HYDRAE CCDFLAT	STIS/CCD	4	01-Jun-2011 23:19:52.0	yes

4 Total Orbits Used

ABSTRACT

The carbon star V Hydra is experiencing heavy mass loss as it undergoes the transition from AGB star to pre-planetary nebula. 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, in Jan 2002, we discovered a high-velocity (> 200 km/s) jet or blob of gas in V Hya which had been ejected a few years prior from near the star. 2nd and 3rd epoch STIS observations over 2 years clearly revealed both its proper motion and strong deceleration. We propose STIS monitoring of this remarkable event over a period of 3 years, in order to obtain a precise dynamical and cooling history of this blob and any successor blobs that may have been ejected since then. This ejection event is likely to hold the key to

understanding why initially spherical mass outflows adopt a bipolar geometry during the post-AGB phase of stellar evolution. The goal is to understand the interaction of the blobby jet outflow with the ambient circumstellar medium. We not only have the opportunity to look on as the circumstellar envelope is sculpted by this and perhaps other collimated mass ejections, but we also have an unprecedented chance to constrain the mechanism for mass ejection, and thereby help solve the long-standing puzzle of how the spherical mass-loss envelopes of AGB stars evolve into bipolar planetary nebulae.

OBSERVING DESCRIPTION

We will utilise the same observing set-up as in GO 9800. We will use STIS with G430M (tilt setting of 4194) and the 52"$\times$0\farcs1 to obtain spectra in the $\lambda\lambda$4051-4337{\AA} range. From our previous data, the [SII]λ4066{\AA} line has a peak intensity of 4$\times10^{-13}$ erg s^{-1} cm^2 {\AA}$^{-1}$ arcsec^{-2}. We will use somewhat larger exposure times ($\sim$720\,s) compared to GO\,9800 (520\,s total per slit position) to account for possible weakening of the blob brightness, using a 3 point dither along the slit, and CR-SPLIT=2, which gives us a S/N$\gsim$60-70 at peak of the [SII]λ4066{\AA} line, and a S/N$\gsim$15 at the continuum (which is roughly a factor 4 weaker in the -0\farcs1 slit, where the high-velocity outflow 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 to sub-pixel accuracy, which is important since the proper motion is about 0\farcs07 per year (and may decrease with time, if deceleration of the blob continues). In addition, we want to continue to be able to detect important fainter lines ([FeII]λ4241 \& 4285{\AA}) (which we have detected previosly) which provide additional probes of the physical conditions in the outflow. Since our most important objective is to understand the velocity field of the jets in order to study the collimation process, we will obtain spectra with 2 additional slit positions displaced symmetrically on either side of the central star (i.e. with offsets of $\pm$0\farcs1 and $\pm$0\farcs2). The G430M observations will require slightly more than 3.5 orbits.

The remainder of the last orbit will be used for the observations of the ``central disk" in H$\alpha$, we will use a mosaic of 3 adjacent slit positions, using the 52"$\times$0\farcs1wide slit -- the narrow slit is used here (in contrast to the G430M observations) in order to obtain the highest spectral resolution because the velocity range covered by the ``disk" emission is much smaller (about 90\kms). The Hα disk intensity at the half-power point is about 5$\times10^{-12}$ erg s^{-1} cm^2 {\AA}$^{-1}$ arcsec^{-2}; we will use exposure times of 300 sec total per slit (CR-SPLIT=2 and a 3-point dither along slit) to obtain a S/N of 40 (after subtraction of the continuum background) -- such a high S/N is necessary to characterise the disk velocity structure with the limited spectral resolution (50\kms). Our slit mosaic will cover a total of 0\farcs3 across the central region -- such a mosaic is necessary because in our previous Hα STIS observations, the disk was clearly seen only in the offset slits. The presence of the very strong stellar continuum in the central slit and imperfect rectification, resulting in very strong undulations along the wavelength

direction -- makes it difficult to subtract the continuum, which is necessary in order to detect the weaker disk signal. We will use a 3-point dither strategy.

The available windows for observing V Hya given our STIS slit ORIENT constraints (we require an ORIENT within $\pm$4\arcdeg~of the one in first two epochs) occur twice (1) in June/July, and (2) Dec/Jan/Feb each calendar year. We will request observing dates with an attempt to ensure that at least one epoch falls near (i.e. within a month) of maximum light, while a second one fall near minimum light of the 529 day period of this object. Such scheduling will allow us to check if there is any effect of the stellar light cycle on the outflow.

Visit

Proposal 12227, Visit 01, implementation Thu Jun 02 03:20:05 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

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

Patterns

#	Primary Pattern		Secondary Pattern		Exposures
(1)	Pattern Type=STIS-PERP-TO-SLIT Purpose=MOSAIC Number Of Points=3 Point Spacing=0.2 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0.0 Angle Between Sides= Center Pattern=true	Pattern Type=STIS-ALONG-SLIT Purpose=DITHER Number Of Points=3 Point Spacing=0.22851 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=90.0 Angle Between Sides= Center Pattern=false	(3)
(2)	Pattern Type=STIS-PERP-TO-SLIT Purpose=MOSAIC Number Of Points=3 Point Spacing=0.2 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0.0 Angle Between Sides= Center Pattern=true	Pattern Type=STIS-ALONG-SLIT Purpose=DITHER Number Of Points=3 Point Spacing=0.22851 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=90.0 Angle Between Sides= Center Pattern=false	(4)
(3)	Pattern Type=STIS-ALONG-SLIT Purpose=DITHER Number Of Points=3 Point Spacing=0.22851 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=90.0 Angle Between Sides= Center Pattern=false			(5)

Fixed Targets

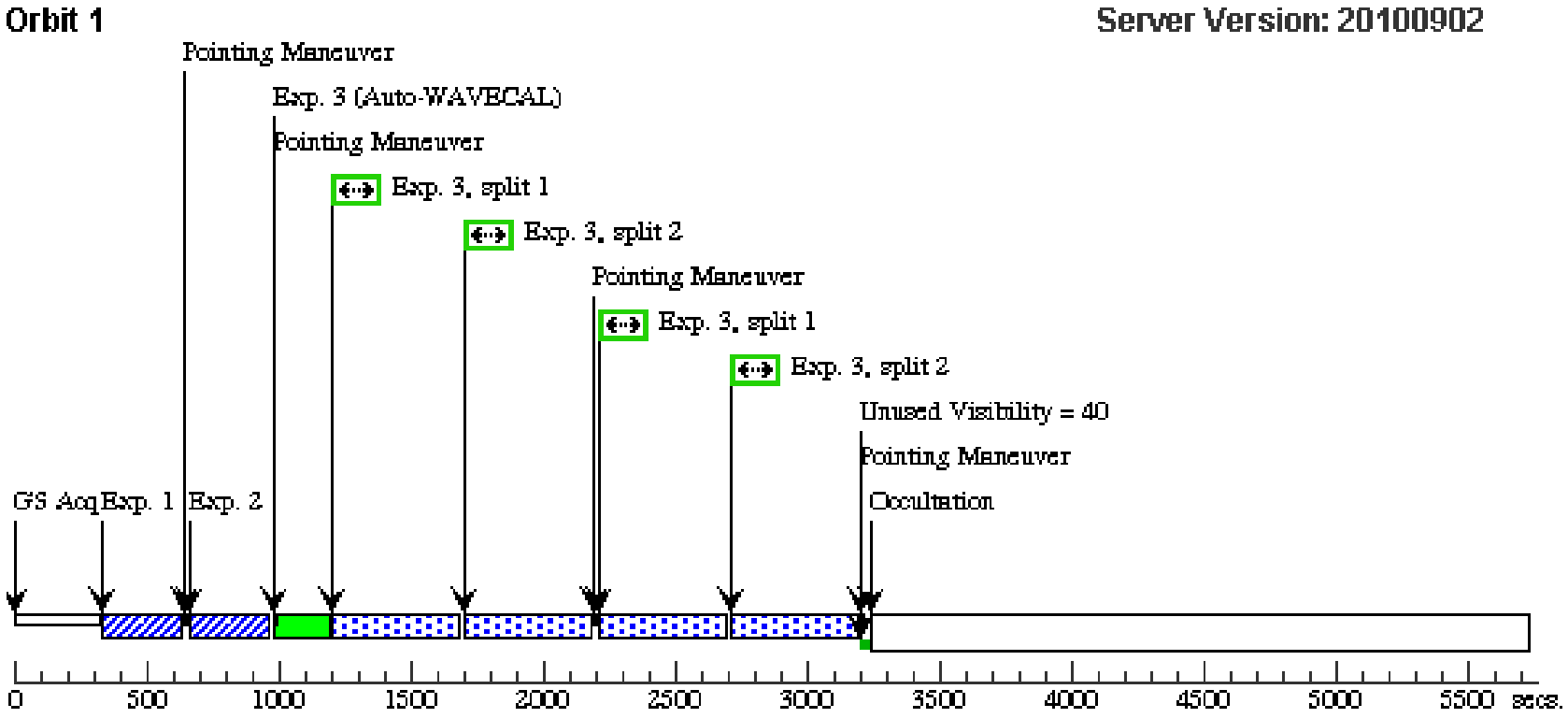
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-HYDRAE	RA: 10 51 37.2550 (162.9052292d) Dec: -21 15 0.32 (-21.25009d) Equinox: J2000	Proper Motion RA: -0.00101 sec of time/yr Proper Motion Dec: 0.00272 arcsec/yr Epoch of Position: 1991.25	V=9.7	Reference Frame: ICRS

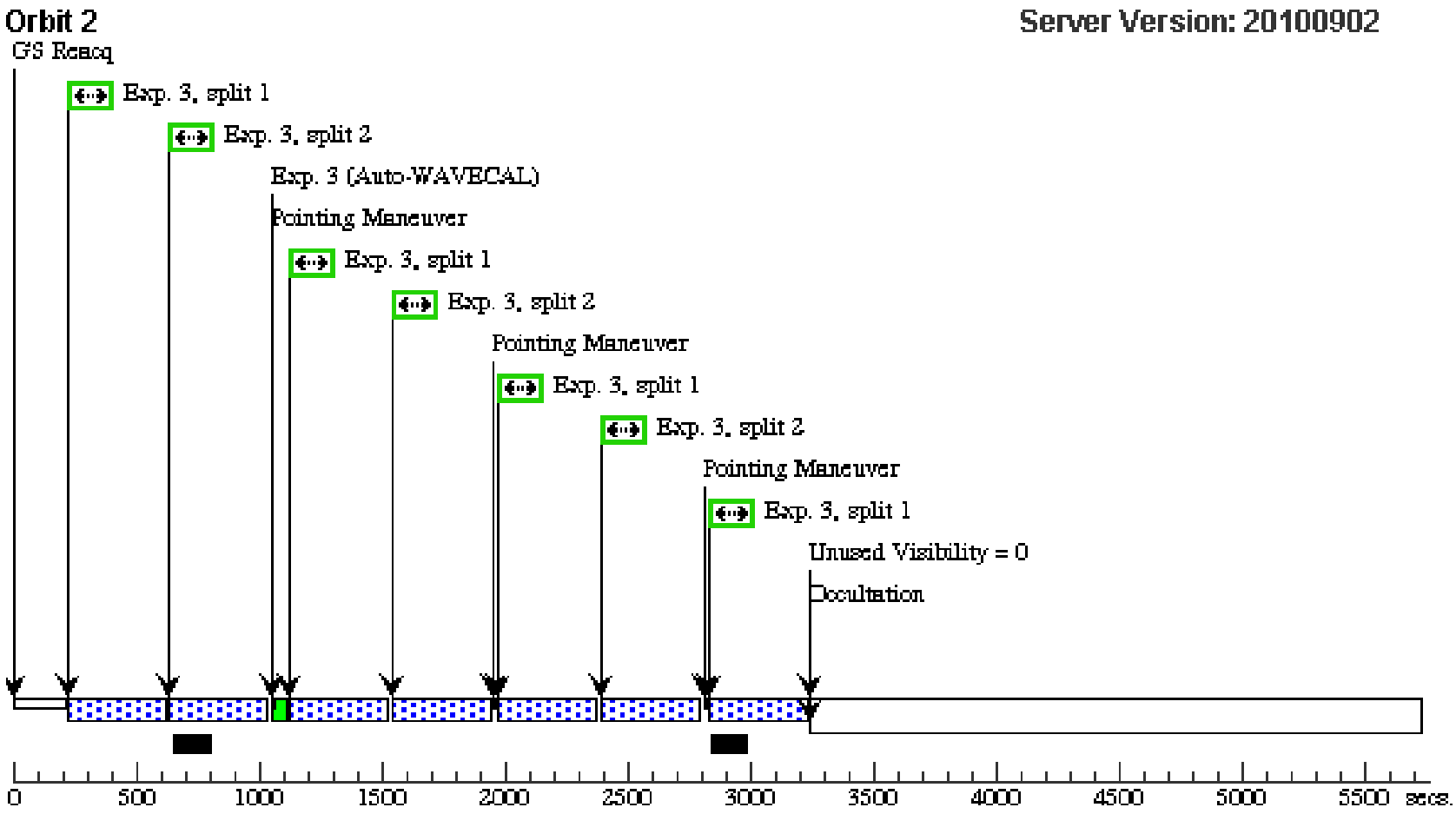
Exposures

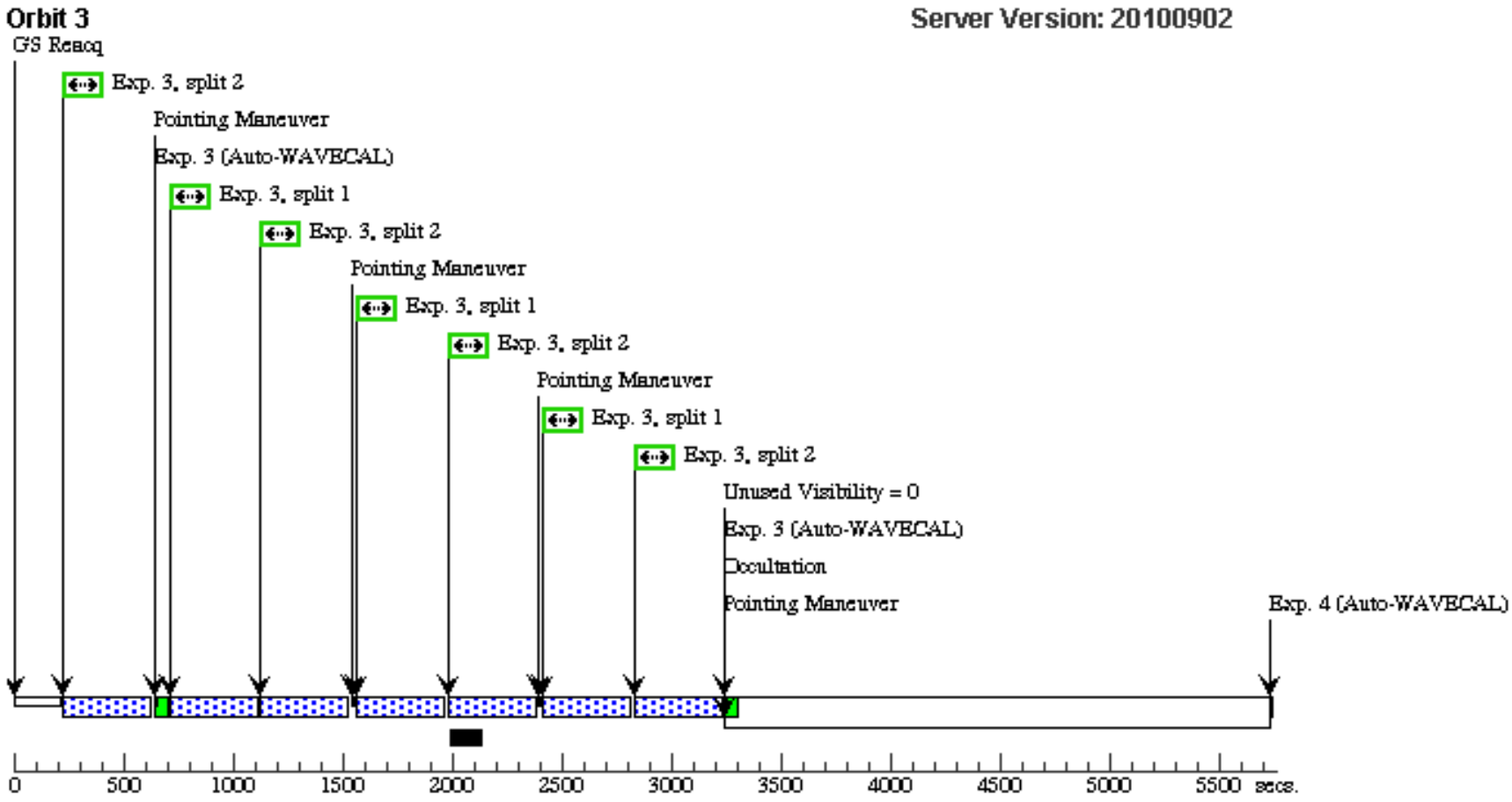
#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) V-HYDRAE	STIS/CCD, ACQ, F25ND3	MIRROR				1.3 Secs	
								[==>]	***[1]***
Comments: mosaic of 3 slits aligned along the outflow, spaced apart by 0.3 arcsec; for each slit position, a 3-point dither in steps of 0.225 arcsec									
2		(1) V-HYDRAE	STIS/CCD, ACQ/PEAK, 52X0.1	G750L				1.0 Secs	
				7751 A				*[==>]*	***[1]***
Comments: mosaic of 3 slits aligned along the outflow, spaced apart by 0.2 arcsec; for each slit position, a 3-point dither in steps of 0.225 arcsec									
3		(1) V-HYDRAE	STIS/CCD, ACCUM, 52X0.2	G430M			Pattern 1, Exps 3-3 in Visit 01 (1)	770 Secs	
				4194 A				*[==>449.0 Secs (Pattern 1,1, Split 1)]* *[==>449.0 Secs (Pattern 1,1, Split 2)]* *[==>449.0 Secs (Pattern 1,2, Split 1)]* *[==>449.0 Secs (Pattern 1,2, Split 2)]*	***[1]***
								[==>369.0 Secs (Pattern 1,3, Split 1)] *[==>369.0 Secs (Pattern 1,3, Split 2)]* *[==>369.0 Secs (Pattern 2,1, Split 1)]* *[==>369.0 Secs (Pattern 2,1, Split 2)]* *[==>369.0 Secs (Pattern 2,2, Split 1)]* *[==>369.0 Secs (Pattern 2,2, Split 2)]* *[==>369.0 Secs (Pattern 2,3, Split 1)]*	***[2]***
								[==>369.0 Secs (Pattern 2,3, Split 2)] *[==>369.0 Secs (Pattern 3,1, Split 1)]* *[==>369.0 Secs (Pattern 3,1, Split 2)]* *[==>369.0 Secs (Pattern 3,2, Split 1)]* *[==>369.0 Secs (Pattern 3,2, Split 2)]* *[==>369.0 Secs (Pattern 3,3, Split 1)]* *[==>369.0 Secs (Pattern 3,3, Split 2)]*	***[3]***
Comments: 9 exposures to produce a mosaic of 3 slits, spaced apart by 0.2 arcsec, with a 3-point dither along the slit for each slit position									

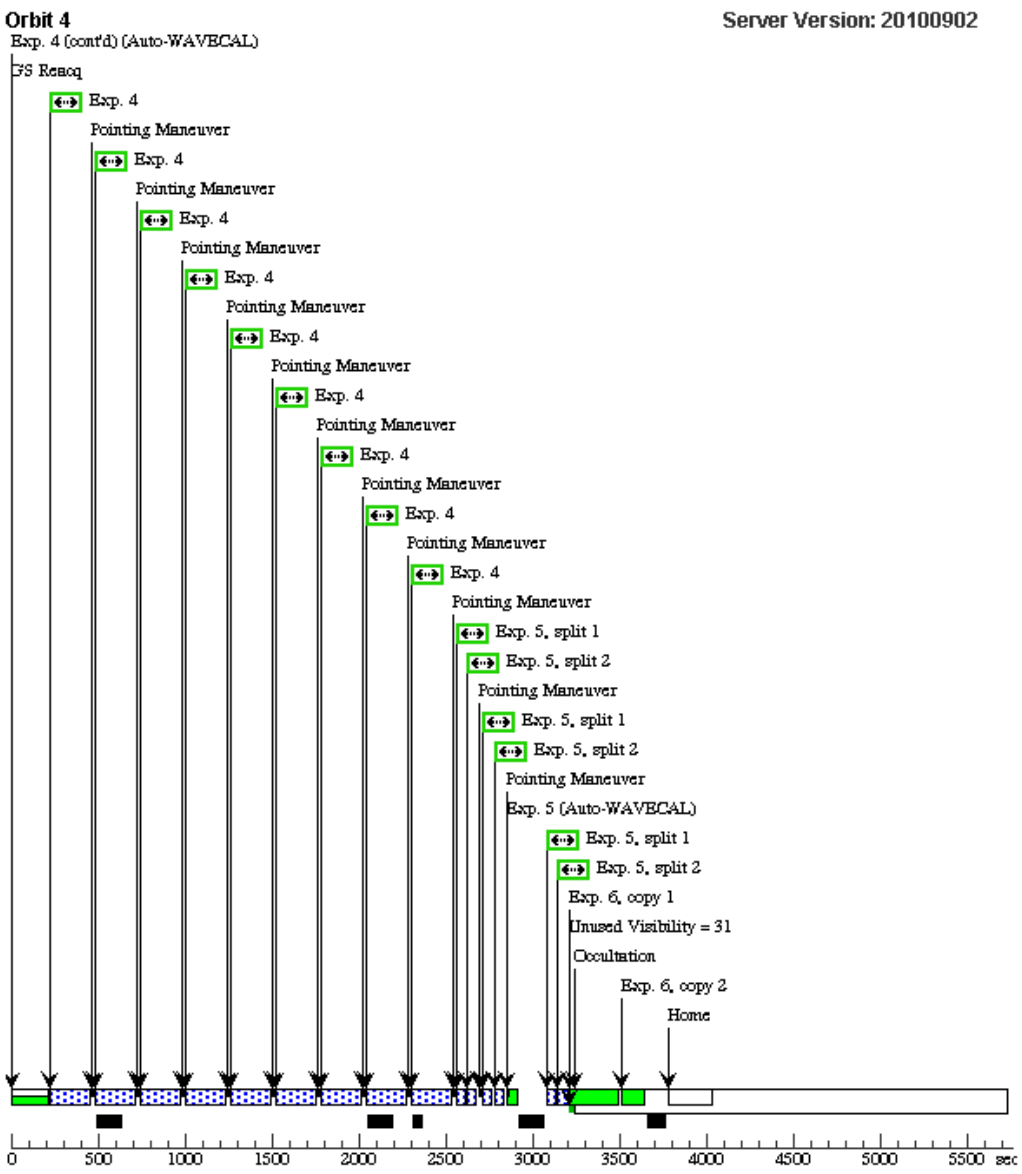
	4	(1) V-HYDRAE	STIS/CCD, ACCUM, 52X0.1	G750M 6581 A	CR-SPLIT=NO	Pattern 2, Exps 4-4 in Visit 01 (2)	75 Secs	
							[==>190.0 Secs (Pattern 1,1)] *[==>190.0 Secs (Pattern 1,2)]* *[==>190.0 Secs (Pattern 1,3)]* *[==>190.0 Secs (Pattern 2,1)]* *[==>190.0 Secs (Pattern 2,2)]* *[==>190.0 Secs (Pattern 2,3)]* *[==>190.0 Secs (Pattern 3,1)]* *[==>190.0 Secs (Pattern 3,2)]* *[==>190.0 Secs (Pattern 3,3)]*	***[4]***
	Comments: 9 exposures to produce a mosaic of 3 slits, spaced apart by 0.1 arcsec, with a 3-point dither along the slit for each slit position							
	5	(1) V-HYDRAE	STIS/CCD, ACCUM, 52X0.1	G750M 6581 A		Pattern 3, Exps 5-5 in Visit 01 (3)	10 Secs	
							[==>20.0 Secs (Pattern 1, Split 1)] *[==>20.0 Secs (Pattern 1, Split 2)]* *[==>20.0 Secs (Pattern 2, Split 1)]* *[==>20.0 Secs (Pattern 2, Split 2)]* *[==>20.0 Secs (Pattern 3, Split 1)]* *[==>20.0 Secs (Pattern 3, Split 2)]*	***[4]***
	Comments: 9 exposures to produce a mosaic of 3 slits, spaced apart by 0.1 arcsec, with a 3-point dither along the slit for each slit position							
	6	CCDFLAT	STIS/CCD, ACCUM, 52X0.05	G750L 7751 A			62.5 Secs X 2	
							[==>(Copy 1)] *[==>(Copy 2)]*	***[4]***

Orbit Structure




Orbit 2
Server Version: 20100902
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
Unused Visibility = 0
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 3
Server Version: 20100902
GS Reacq
Exp. 3, split 2
Pointing Maneuver
Exp. 3 (Auto-WAVECAL)
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 Visibility = 0
Exp. 3 (Auto-WAVECAL)
Occultation
Pointing Maneuver
Exp. 4 (Auto-WAVECAL)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 4
Server Version: 20100902
Exp. 4 (cont'd) (Auto-WAVECAL)
FGS Reacq
Exp. 4
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 5, split 1
Exp. 5, split 2
Pointing Maneuver
Exp. 5, split 1
Exp. 5, split 2
Pointing Maneuver
Exp. 5 (Auto-WAVECAL)
Exp. 5, split 1
Exp. 5, split 2
Exp. 6, copy 1
Unused Visibility = 31
Occultation
Exp. 6, copy 2
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec