16232 - Investigating The Interstellar Bullet Engine IRAS05506+2414

Cycle: 28, 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 Claussen (CoI)	Associated Universities, Inc.	mclausse@aoc.nrao.edu
Dr. Mark R. Morris (CoI)	University of California - Los Angeles	morris@astro.ucla.edu
Dr. Carmen Sanchez Contreras (CoI) (ESA Member)	Centro de Astrobiologia (CSIC/INTA) Inst. Nac. de Tec. Aero.	csanchez@cab.inta-csic.es
Dr. Nimesh Patel (CoI)	Harvard University	npatel@cfa.harvard.edu
Dr. Chin-Fei Lee (CoI)	Academia Sinica, Institute of Astronomy and Astrophysics	cflee@asiaa.sinica.edu.tw
Prof. John Bally (CoI)	University of Colorado at Boulder	john.bally@colorado.edu

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
03	(1) IRAS05506+2414 (2) N30120321186	STIS/CCD	2	18-Dec-2020 17:00:13.0	yes
04	(1) IRAS05506+2414	WFC3/IR WFC3/UVIS	3	18-Dec-2020 17:00:16.0	yes

5 Total Orbits Used

ABSTRACT

An exciting development in the understanding of the early evolutionary stages of massive stars, based on a new study of the Orion BN/KL region, is that the disruption of a massive young stellar system can lead to an explosive event producing a wide-angle outflow - an entirely different

phenomenon from the classical bipolar flows driven by YSO accretion disks. We have discovered an object, IRAS05506+2414, which may be the 2nd clear-cut example of this phenomenon. Our HST optical and near-IR images show a fan-like spray of high-velocity (up to 350 km/s) elongated knots which appear to emanate from a bright compact central source; we find that the physical properties (opening angle, outflow speeds, knot masses, Herbig-Haro-object like optical line emission) of the IRAS05506 wide-angle outflow are very similar to those seen in Orion.

We propose to determine IRAS05506's distance from a measurement of the knot proper motions using WFC3 to obtain a 2nd epoch F606W image. Only then will we be able to robustly constrain the central star's luminosity and mass and the dynamical time-scale, mass, velocity, and kinetic energy distributions of its outflows -- needed to test possible mechanisms for the explosive disintegration model for such sources. Deep emission-line imaging with WFC3 will be used to probe the full size and structure of the bullet spray. We will use STIS to confirm the presence of a second outflow engine in IRAS05506: an intriguing linear feature that looks like a classical YSO collimated jet can be seen emanating from the central source, but only a long-slit spectrum of the line emission with sufficient angular resolution can confirm it to be a high-velocity jet.

OBSERVING DESCRIPTION

\noindent$\bullet$ {\bf WFC3/UVIS} -- We will obtain a deep 2nd-epoch image of IRAS\,05506 using WFC3/UVIS (since ACS/HRC is no longer functional), but with longer exposure times than the the 1st epoch (discovery) observations -- covering one orbit (in which the HRC was used with 2$\times$400\,s exposures). This observation will enable proper motion determination with an accuracy better than 15\,\kms$\times$(D/2.8\,kpc). The longer exposure time will enable a more accurate comparison with the WFC3 emission line imaging, which is needed in order to distinguish emission-line knots from dusty substructure. For the deep optical emission-line imaging needed to probe the full azimuthal and radial extent of the knotty outflow, we will use the WFC3/UVIS camera and the Hα+[NII] (F657N) filter. It is better suited for sampling the knots than ACS/WFC because of its smaller pixels (0.04${"}$ compared to 0.05${"}$).

\noindent$\bullet$ {\bf WFC3/IR} -- We will carry out high S/N imaging with WFC3/IR in the [FeII]\,1.64\micron~emission-line and related continuum filters (F164N, F167N) in order to look for high-velocity knots with shocked gas near the central source, where the extinction is high and therefore not well-probed by the optical emission-line imaging. Shock models (Hartigan et al.\,2004) show that the [FeII]\,1.64\micron~emission is comparable or stronger than the optical forbidden line emission (e.g. in [OI]6300) for a variety of shock conditions (shock velocity, preshock density and ionization fraction etc.). Hence, the average [FeII] 1.64\micron~brightness in knot $K1$ is expected to be about 9×10^{-15} erg s^{-1} cm^2 arcsec^{-2}. We will therefore use exposure times of about 15 minutes for each of the F164N\,\&\,F167N filters, allowing us to detect knots which are fainter by a factor $\gtrsim$5 than $K1$. We are requesting the F167N narrow filter for continuum subtraction, because using the

broad-band filter (see below) for subtraction in a region of large and variable extinction gives very poor results.

We will use the F110W and F160W filters to distinguish faints stars from compact knots seen in the [FeII]\,1.64\micron~image. Integration times of about 200 and 80\,s with WFC3 provide S/N of about 40 each in the F110W and F160W images. This high S/N will also improve the characterisation of many faint filamentary structures seen in the vicinity of the central source.

\noindent$\bullet$ {\bf STIS} -- We will use STIS with G750M and the 52"$\times$0\farcs1 slit to obtain spectra in the $\lambda\lambda$6295-6867{\AA} range with $\sim$50\,\kms~spectral and 0.05 arcsec spatial resolution. The slit will be aligned along the jet, i.e. PA=238\arcdeg. We will thus cover the Hα, [NII]\,6548,6583 and [SII]\,6717,6731 lines; the [OI]6300 line will be near the edge, but still visible. The jet {\it Sa-jet(?)} is roughly 0.05 arcsec wide and about 0.2 arcsec long in the F606W ACS image. The Hα average line intensity is 4.8$\times10^{-15}$ erg s^{-1} cm^2 arcsec^{-2} over a velocity width of about 130\,\kms, and a factor of 3.5 larger at the peak. The [SII]\,6717,6731 lines are 61\%,\,94\% of the Hα brightness. We will need an exposure time of about 70 minutes (i.e. 2 orbits) which gives us a S/N$\gsim$12 at the peak, and about 5 at a velocity offset of 130\,\kms. This S/N ratio is adequate to allow us to centroid the line peak to significantly better than 10\,\kms.

From the observed PA of {\it Sa-jet(?)}, 50\arcdeg, we compute an $ORIENT=PA+46.3\arcdeg\sim96\arcdeg$ or $PA+226.3\arcdeg\sim276\arcdeg$ (as per the STIS handbook). We therefore request a slit ORIENT in the range 92\arcdeg--100\arcdeg, or 272\arcdeg-280\arcdeg, in order to probe the emission from the highly-collimated jet precisely. This ORIENT range, although restricted, allows many available windows for scheduling. We have also checked with the Help desk that we can use Sa for registering the slit. Several brighter stars are also available for offset imaging, if in case during Phase II, we determine that the latter is the better option. We will use the STScI recommended dithering patterns for all data taken with the WFC3 and STIS in order to optimally sample the PSF.

Visit

Proposal 16232, Visit 03, implementation Fri Dec 18 22:00:17 GMT 2020

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: ORIENT 92D TO 100 D; ORIENT 272D TO 280 D

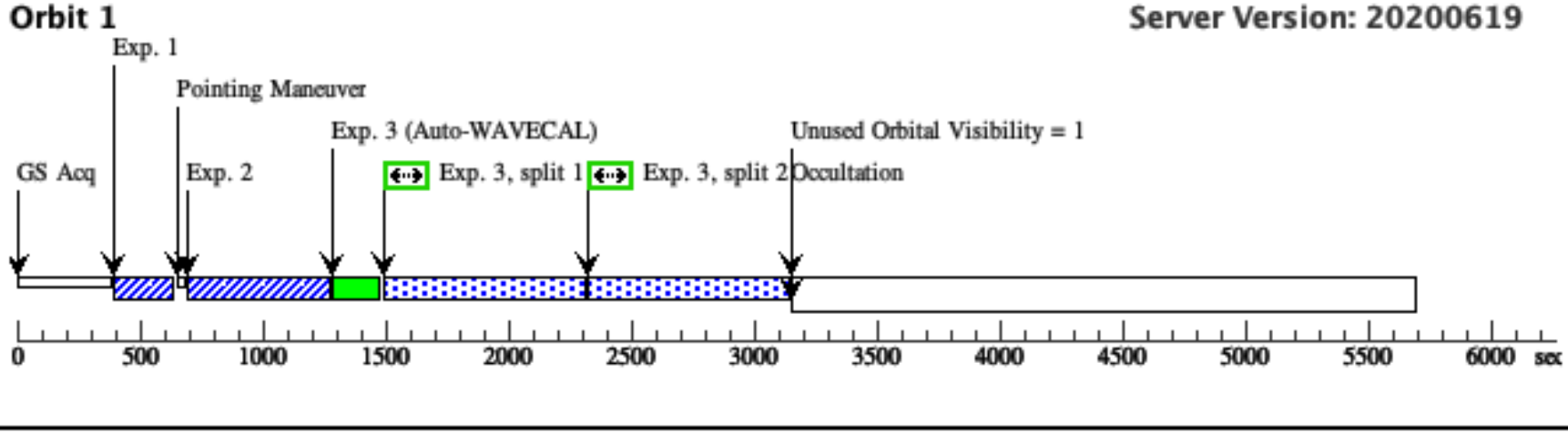
Fixed Targets

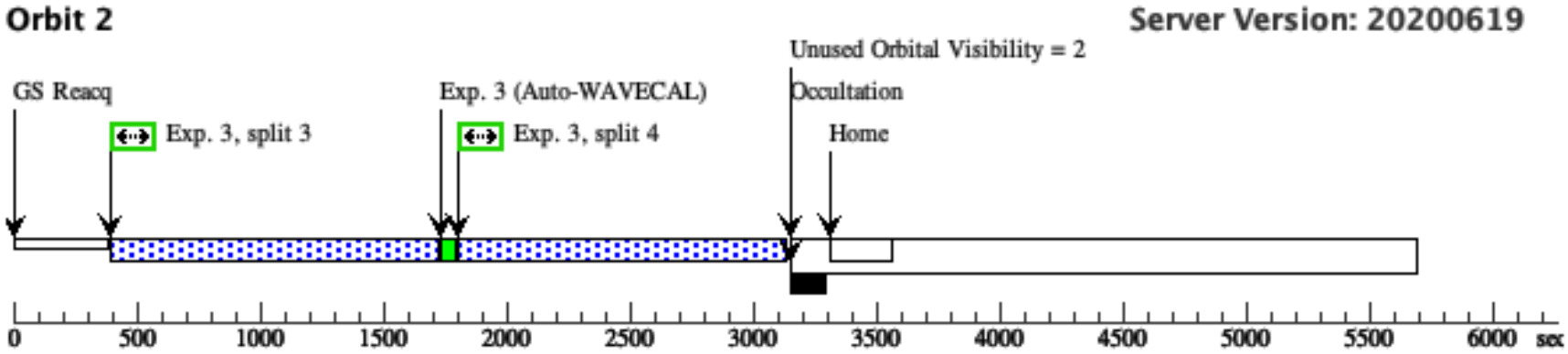
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	IRAS05506+2414	RA: 05 53 43.5600 (88.4315000d) Dec: +24 14 44.70 (24.24575d) Equinox: J2000	Proper Motion RA: 0 sec of time/yr Proper Motion Dec: 0 arcsec/yr Parallax: 0"	V=15.4+/-1.0 R=15.4	Reference Frame: ICRS
Comments: *Category=ISM* *Description=[REFLECTION NEBULA]*					
(2)	N30120321186	RA: 05 53 41.1932 (88.4216383d) Dec: +24 14 41.79 (24.24494d) Equinox: J2000	Proper Motion RA: 5.761 mas/yr Proper Motion Dec: 1.267 mas/yr Epoch of Position: 2015.5	V=14.638+/-0.1 Rmag=13.7	Reference Frame: ICRS
Comments: *Category=STAR* *Description=[G V-IV]* *Extended=NO*					

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.1470228)	(2) N30120321186	STIS/CCD, ACQ, 50CCD	MIRROR				1 Secs (1 Secs)	
								[==>]	***[1]***
2	(STIS.ta.1473484)	(1) IRAS05506+2414	STIS/CCD, ACQ/PEAK, 52X0.1	MIRROR				30 Secs (30 Secs)	
								[==>]	***[1]***
3		(1) IRAS05506+2414	STIS/CCD, ACCUM, 52X0.1	G750M 6581 A	CR-SPLIT=4			2400 Secs (4160 Secs)	
								[==>786.0 Secs (Split 1)] *[==>786.0 Secs (Split 2)]*	***[1]***
								[==>1294.0 Secs (Split 3)] *[==>1294.0 Secs (Split 4)]*	***[2]***

Orbit Structure





Visit

Proposal 16232, Visit 04, implementation Fri Dec 18 22:00:17 GMT 2020

Diagnostic Status: Warning

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: (none)

Diagnostics

(Exposure 1 (Pattern 3, Exps 1-2 in Visit 04)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 2 (Pattern 3, Exps 1-2 in Visit 04)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 3 (Pattern 1, Exps 3-3 in Visit 04)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 4 (Pattern 3, Exps 4-4 in Visit 04)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(3)
(2)	Pattern Type=WFC3-IR-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.636 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=41.788 Angle Between Sides= Center Pattern=false		(5-8)
(3)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1-2), (4)

Fixed Targets

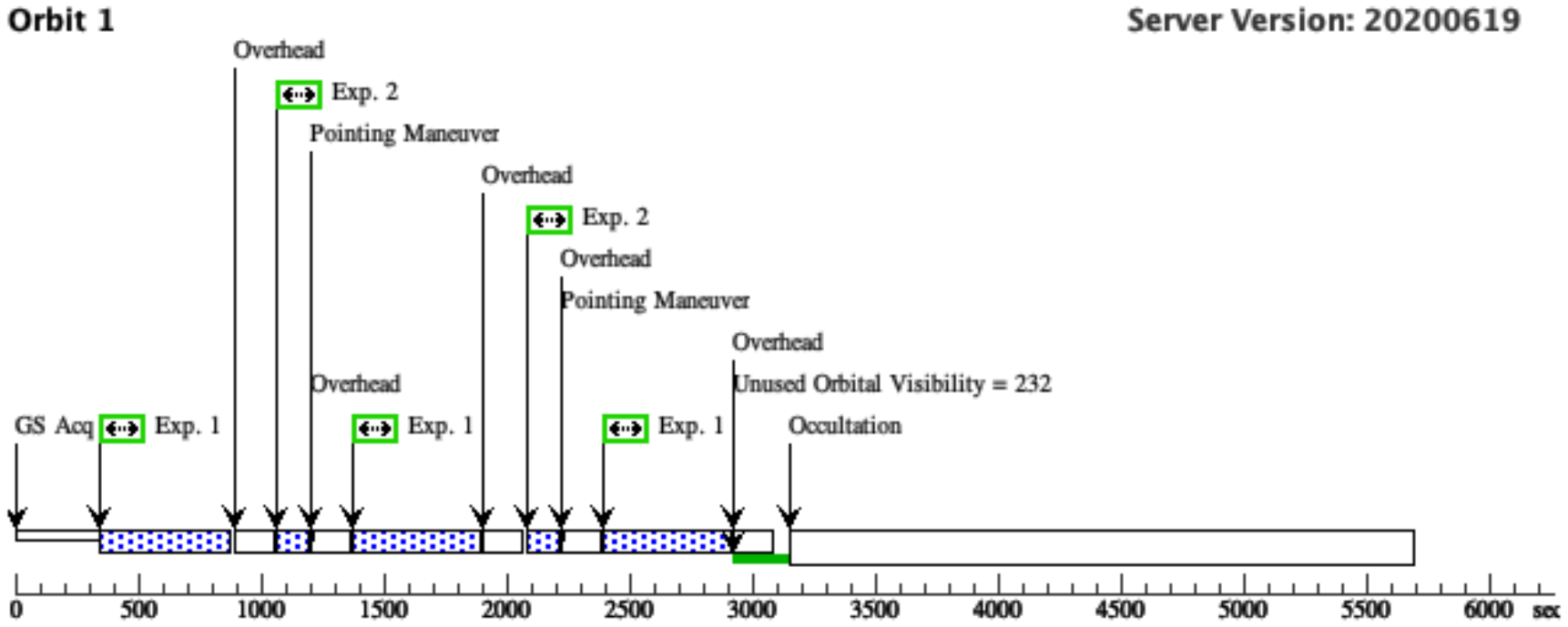
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	IRAS05506+2414	RA: 05 53 43.5600 (88.4315000d) Dec: +24 14 44.70 (24.24575d) Equinox: J2000	Proper Motion RA: 0 sec of time/yr Proper Motion Dec: 0 arcsec/yr Parallax: 0"	V=15.4+/-1.0 R=15.4	Reference Frame: ICRS

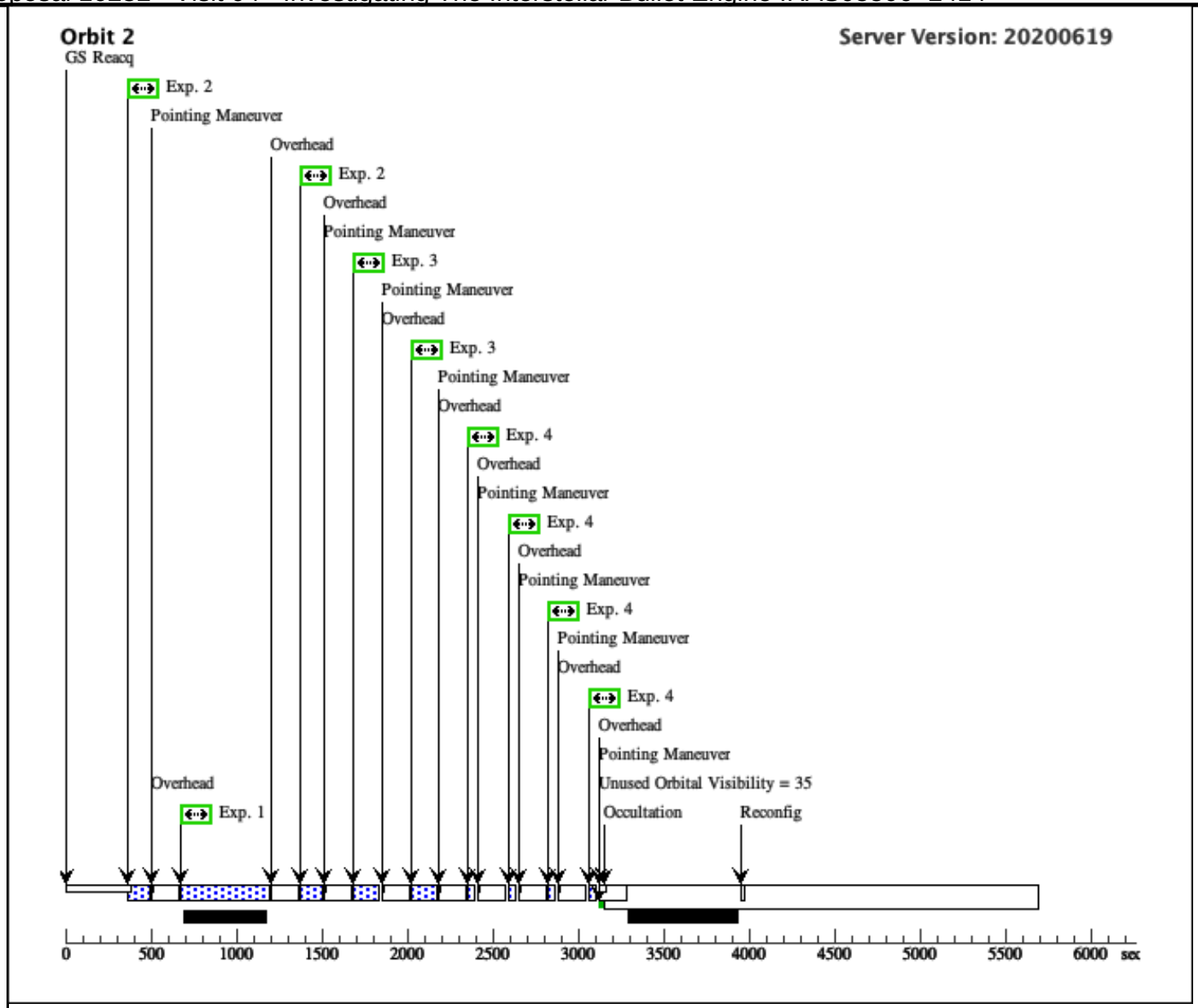
Comments:
Category=ISM
Description=[REFLECTION NEBULA]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) IRAS05506+2414	WFC3/UVIS, ACCUM, UVIS1-2K2A-SUB	F657N	FLASH=18		Pattern 3, Exps 1-2 in Visit 04 (3)	500 Secs (2000 Secs)	
								[==>(Pattern 1)]	
								[==>(Pattern 2)]	***[1]***
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	***[2]***
2		(1) IRAS05506+2414	WFC3/UVIS, ACCUM, UVIS1-2K2A-SUB	F606W	FLASH=14		Pattern 3, Exps 1-2 in Visit 04 (3)	100 Secs (400 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	***[2]***
								[==>(Pattern 4)]	
3		(1) IRAS05506+2414	WFC3/UVIS, ACCUM, UVIS1-2K2A-SUB	F606W	FLASH=14		Pattern 1, Exps 3-3 in Visit 04 (1)	150 Secs (300 Secs)	
								[==>(Pattern 1)]	***[2]***
								[==>(Pattern 2)]	
4		(1) IRAS05506+2414	WFC3/UVIS, ACCUM, UVIS1-2K2A-SUB	F606W	FLASH=18		Pattern 3, Exps 4-4 in Visit 04 (3)	45 Secs (180 Secs)	
								[==>(Pattern 1)]	
								[==>(Pattern 2)]	***[2]***
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	
5		(1) IRAS05506+2414	WFC3/IR, MULTIACCUM, IR-FIX	F167N	NSAMP=10; SAMP-SEQ=STEP100		Pattern 2, Exps 5-8 in Visit 04 (2)	399.231646 Secs (798.463 Secs)	
								[==>(Pattern 1)]	***[3]***
								[==>(Pattern 2)]	
6		(1) IRAS05506+2414	WFC3/IR, MULTIACCUM, IR-FIX	F164N	NSAMP=10; SAMP-SEQ=STEP100		Pattern 2, Exps 5-8 in Visit 04 (2)	399.231646 Secs (798.463 Secs)	
								[==>(Pattern 1)]	***[3]***
								[==>(Pattern 2)]	
7		(1) IRAS05506+2414	WFC3/IR, MULTIACCUM, IR-FIX	F160W	SAMP-SEQ=STEP100; NSAMP=8		Pattern 2, Exps 5-8 in Visit 04 (2)	199.231 Secs (398.462 Secs)	
								[==>(Pattern 1)]	***[3]***
								[==>(Pattern 2)]	
8		(1) IRAS05506+2414	WFC3/IR, MULTIACCUM, IR-FIX	F110W	SAMP-SEQ=STEP100; NSAMP=8		Pattern 2, Exps 5-8 in Visit 04 (2)	199.231 Secs (398.462 Secs)	
								[==>(Pattern 1)]	***[3]***
								[==>(Pattern 2)]	

Orbit Structure




Orbit 2
Server Version: 20200619
GS Reacq
Exp. 2
Pointing Maneuver
Overhead
Exp. 2
Overhead
Pointing Maneuver
Exp. 3
Pointing Maneuver
Overhead
Exp. 3
Pointing Maneuver
Overhead
Exp. 4
Overhead
Pointing Maneuver
Exp. 4
Overhead
Pointing Maneuver
Exp. 4
Pointing Maneuver
Overhead
Exp. 4
Overhead
Pointing Maneuver
Unused Orbital Visibility = 35
Occultation
Reconfig
Overhead
Exp. 1
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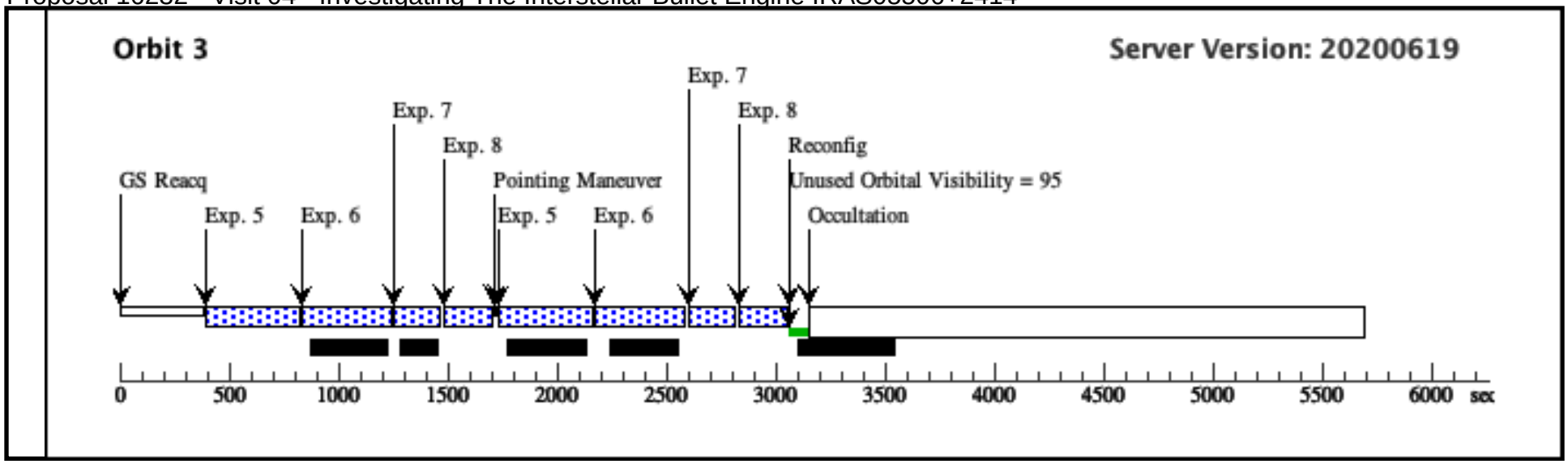
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec


Orbit 3
Server Version: 20200619
GS Reacq
Exp. 5
Exp. 6
Exp. 7
Exp. 8
Pointing Maneuver
Exp. 5
Exp. 6
Exp. 7
Exp. 8
Reconfig
Unused Orbital Visibility = 95
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec