16920 - The Winds and Ionizing Spectra of the Hottest O Stars at Extremely Low Metallicity

Cycle: 29, 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) SA3	COS/FUV COS/NUV	2	29-Mar-2022 11:00:16.0	yes
02	(1) SA3	COS/FUV COS/NUV	2	29-Mar-2022 11:00:17.0	yes
03	(1) SA3	COS/FUV COS/NUV	3	29-Mar-2022 11:00:17.0	yes
04	(1) SA3	COS/FUV COS/NUV	3	29-Mar-2022 11:00:18.0	yes
05	(1) SA3	COS/FUV COS/NUV	2	29-Mar-2022 11:00:19.0	yes

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
06	(1) SA3	COS/FUV COS/NUV	2	29-Mar-2022 11:00:19.0	yes

14 Total Orbits Used

ABSTRACT

Fast-approaching JWST observations of high-redshift galaxies seek to determine the contribution of low-metallicity massive stars to reionization. Yet, the predicted ionizing fluxes of metal-poor O stars are sensitive to uncertain, theoretical mass-loss rates and their downstream effects on stellar rotation and evolution. New observational constraints are required to make progress, but mass-loss measurements from FUV spectra of O stars in nearby galaxies below the metallicity of the SMC (20% Z_sun) remain extremely rare, particularly for the hottest, earliest spectral types that dominate the ionizing photon budget.

We propose G130M and G160M COS observations of a bright, early-O star in Sextans A (6% Z_sun) that was identified in NUV imaging obtained in January 2022. This is just the third known extremely metal-poor, early-O star in any galaxy close enough for detailed study; the other two will both be observed at low spectral resolution by ULLYSES. From these FUV spectra, we will: (1) measure the star's mass-loss rate to test extrapolation of widely used mass-loss recipes to low metallicity; (2) use weak metal line detections to determine which metal ions drive winds in the hottest metal-poor O stars; and (3) provide crucial constraints not possible at lower resolution to maximize the value of the ULLYSES spectra in Sextans A. Combined with archival and ULLYSES data, the proposed observations will form the first empirical benchmark for stellar models that predict the ionizing spectra of reionization-era galaxies. The proposed observations are urgently needed to interpret JWST observations of high-redshift galaxies coming this year and can only be done with HST/COS.

OBSERVING DESCRIPTION

Here we plan observations of a newly identified, hot O star in the nearby, metal-poor galaxy Sextans A with the Cosmic Origins Spectrograph. We will use both the G130M and G160M gratings to get continuous coverage of important stellar wind and photospheric features to determine the mass-loss rates and abundances of this O star to constrain its ionizing photon production.

We obtained initial coordinates by locating the target star in HST imaging with updated WCS information aligned to Gaia DR2. We then identified the target star in the Gaia catalog and adopted the coordinates reported by Gaia for these observations. Gaia reports an astrometric uncertainty of

approximately 1 mas, but we conservatively estimate an uncertainty of 0.05 arcsec to account for any possible offset due to the (very small) proper motion.

We estimate exposure times using the NUV F225W magnitude. We adopt the Milky Way foreground interstellar reddening, since the target's very blue optical and NUV colors are consistent with the intrinsically blue colors of hot O stars. We use the Bruzual O5 V spectral template in the COS ETC, and experimented with similar templates to confirm that the estimated exposure times will achieve SNR ~ 10 per resolution element near key wind features. We use these estimates of exposure times for both target acquisition and spectroscopic observations. All G130M BUFFER-TIMEs are 2/3 times the values reported by the COS ETC, while we adopt 10,000s for the G160M BUFFER-TIME (which is much greater than the orbit-filling exposure time, but less than 20,000, as per the COS handbook).

We will use the ACQ/IMAGE mode with the PSA and Mirror A for target acquisition. Our observations satisfy the BOT safety standards. We organize the observations into visits of at most 3 orbits, as strongly encouraged for Cycle 29 observations.

For all spectroscopic observations, we use TIME-TAG mode with FLASH=YES and SEGMENT=BOTH. We use the G130M grating with the 1291 central wavelength to cover the N V 1240, O V 1371, and Si IV 1400 stellar wind profiles. The G130M configuration only uses FP=3, 4 configurations to satisfy the COS2025 restrictions. We also use the G160M grating with the 1600 central wavelength to cover the Fe V 1428, S V 1502, C IV 1550, He II 1640, and N IV 1719 stellar wind and photospheric profiles. We use FP=All for the G160M observations to extend the possible wavelength coverage.

Visit

Proposal 16920, SA3-G130M (01) Tue Mar 29 15:00:20 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

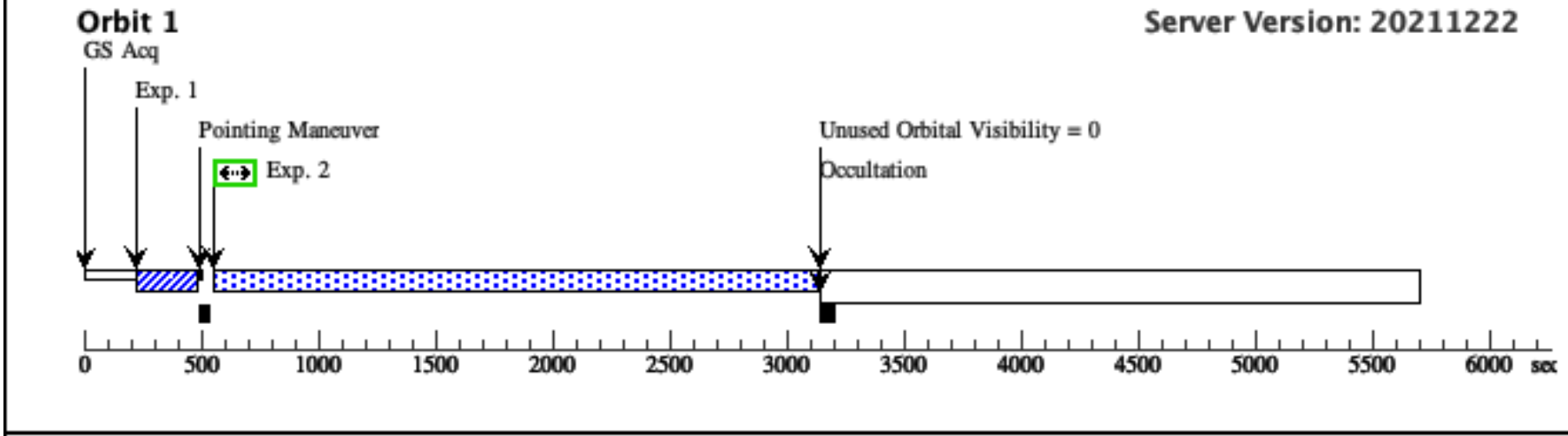
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SA3 Alt Name1: J101104.79-044220.9	RA: 10 11 4.7899 (152.7699579d) Dec: -04 42 20.96 (-4.70582d) Equinox: J2000		V=20.6 F225W = 18.0, F275W = 18.3, F336W = 18.8, F475W = 20.6, F814W = 21.1	Reference Frame: ICRS

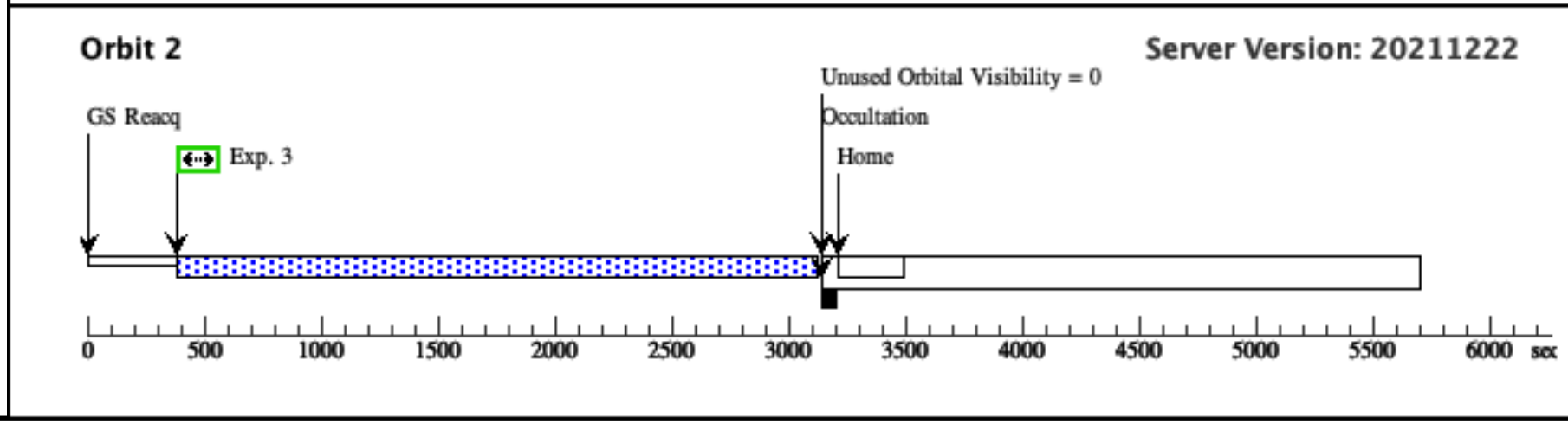
Comments:
Category=EXT-STAR
Description=[MAIN SEQUENCE O]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ (COS.ta.1742872)	(1) SA3	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				14.3 Secs (14.3 Secs) *[==>]*	*[1]*
2	G130M-FPPOS3 (COS.sp.1686148)	(1) SA3	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=4927; FP-POS=3; FLASH=YES; SEGMENT=BOTH			2406 Secs (2406 Secs) *[==>]*	*[1]*
3	G130M-FPPOS4 (COS.sp.1686148)	(1) SA3	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=4927; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	*[2]*

Orbit Structure





Visit

Proposal 16920, SA3-G130M (02) Tue Mar 29 15:00:20 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

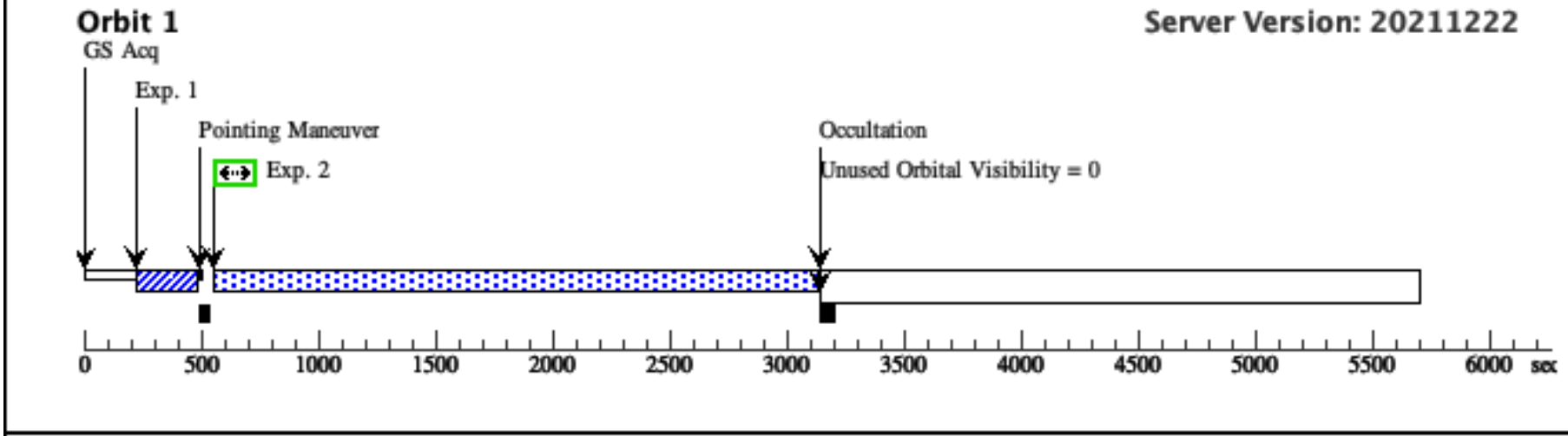
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SA3 Alt Name1: J101104.79-044220.9	RA: 10 11 4.7899 (152.7699579d) Dec: -04 42 20.96 (-4.70582d) Equinox: J2000		V=20.6 F225W = 18.0, F275W = 18.3, F336W = 18.8, F475W = 20.6, F814W = 21.1	Reference Frame: ICRS

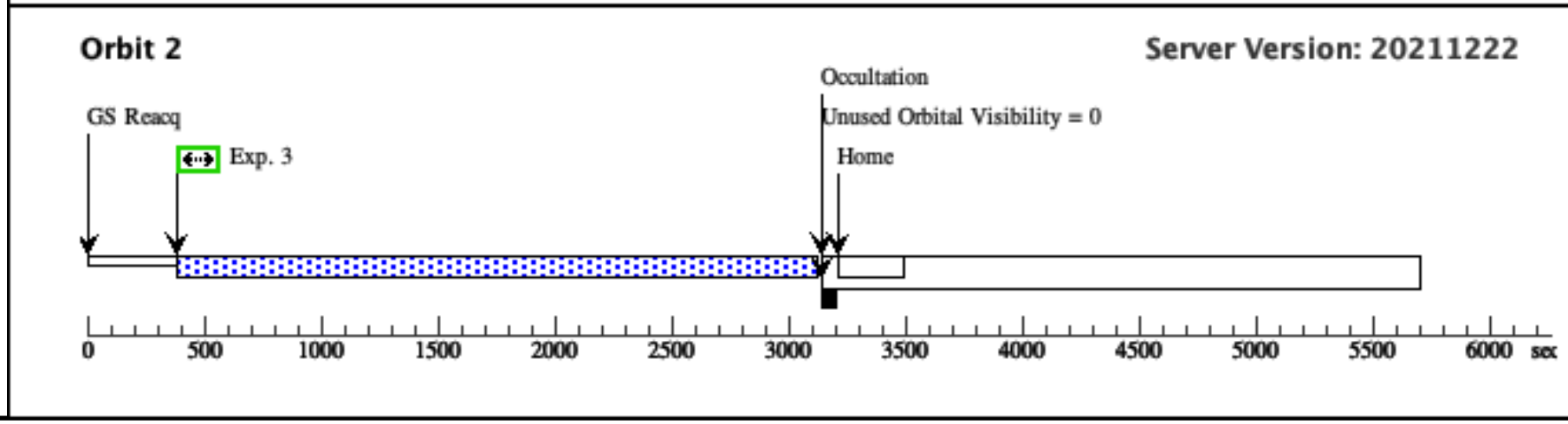
Comments:
Category=EXT-STAR
Description=[MAIN SEQUENCE O]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ (COS.ta.1742872)	(1) SA3	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				14.3 Secs (14.3 Secs) *[==>]*	*[1]*
2	G130M-FPPOS3 (COS.sp.1686148)	(1) SA3	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=4927; FP-POS=3; FLASH=YES; SEGMENT=BOTH			2406 Secs (2406 Secs) *[==>]*	*[1]*
3	G130M-FPPOS4 (COS.sp.1686148)	(1) SA3	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=4927; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	*[2]*

Orbit Structure





Visit

Proposal 16920, SA3-G160M (03) Tue Mar 29 15:00:20 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

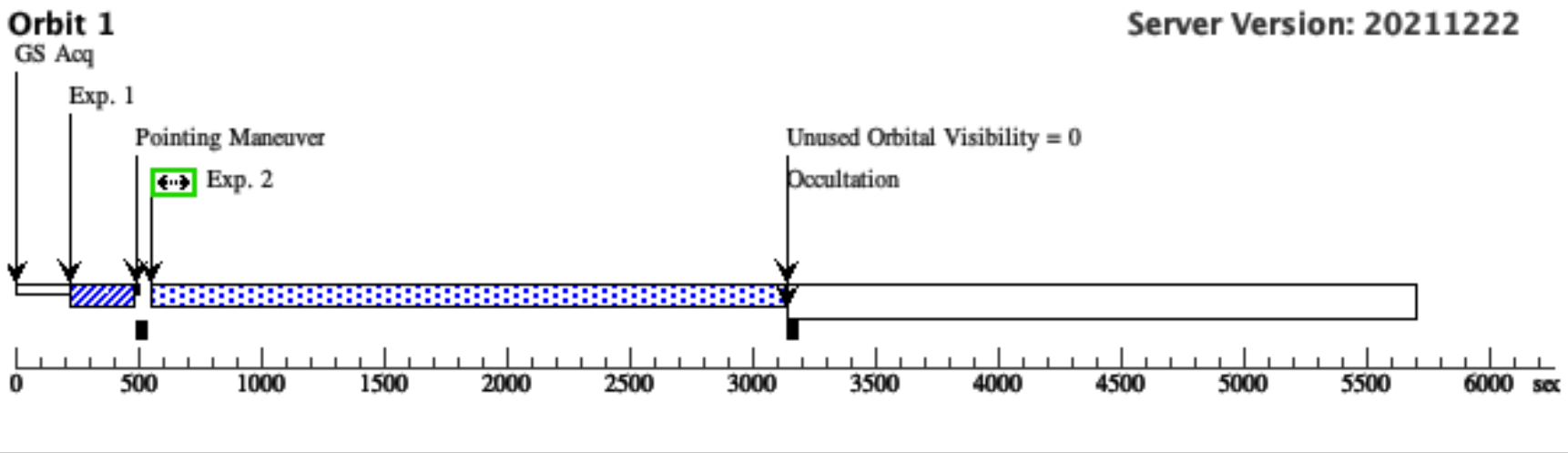
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SA3 Alt Name1: J101104.79-044220.9	RA: 10 11 4.7899 (152.7699579d) Dec: -04 42 20.96 (-4.70582d) Equinox: J2000		V=20.6 F225W = 18.0, F275W = 18.3, F336W = 18.8, F475W = 20.6, F814W = 21.1	Reference Frame: ICRS

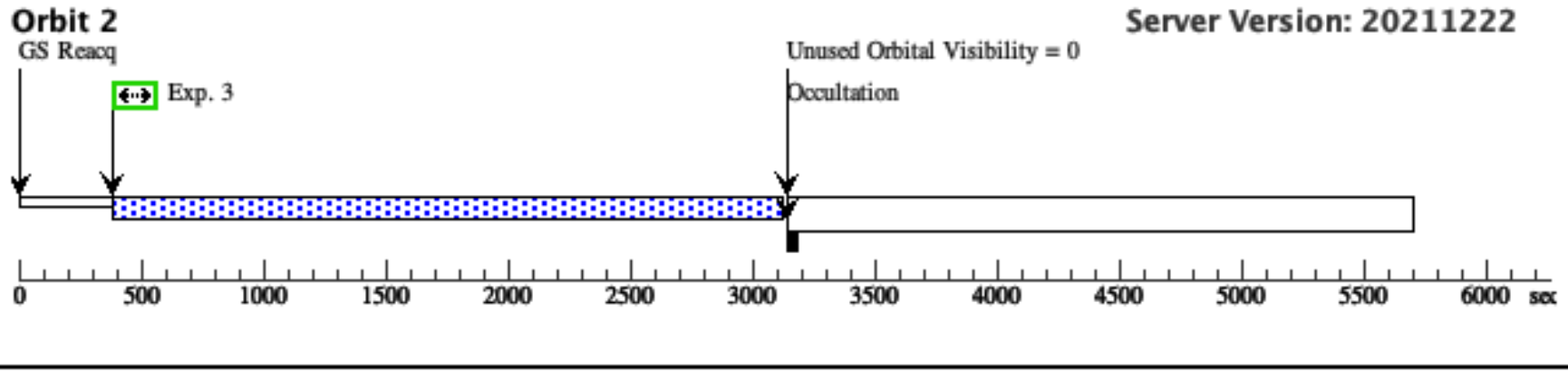
Comments:
Category=EXT-STAR
Description=[MAIN SEQUENCE O]
Extended=NO

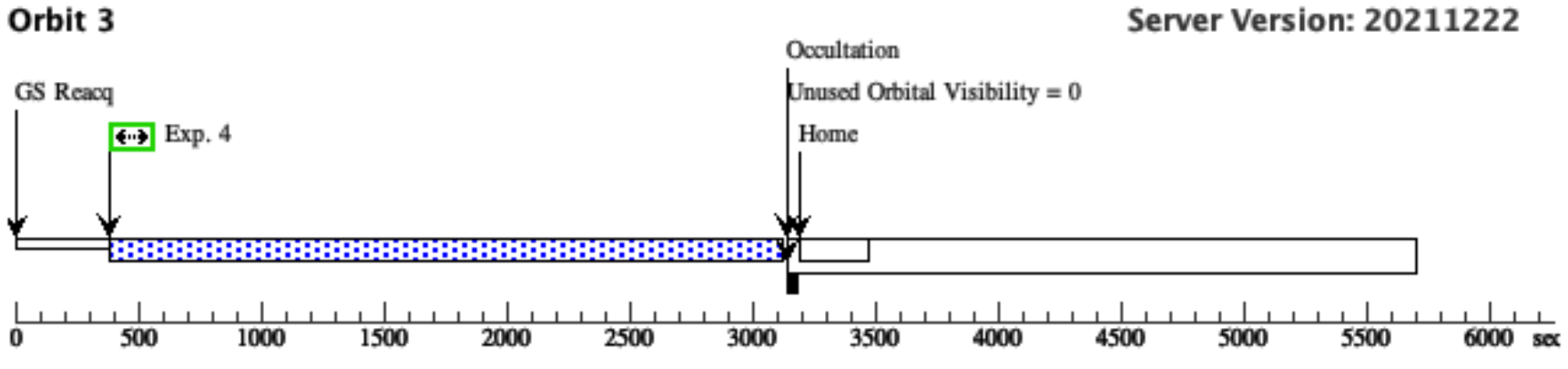
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ (COS.ta.1742873)	(1) SA3	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				14.3 Secs (14.3 Secs) *[==>]*	*[1]*
2	G160M-FPPOS1 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=1; FLASH=YES; SEGMENT=BOTH			2360 Secs (2360 Secs) *[==>]*	*[1]*
3	G160M-FPPOS2 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=2; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	*[2]*
4	G160M-FPPOS3 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=3; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	*[3]*

Orbit Structure







Visit

Proposal 16920, SA3-G160M (04) Tue Mar 29 15:00:20 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

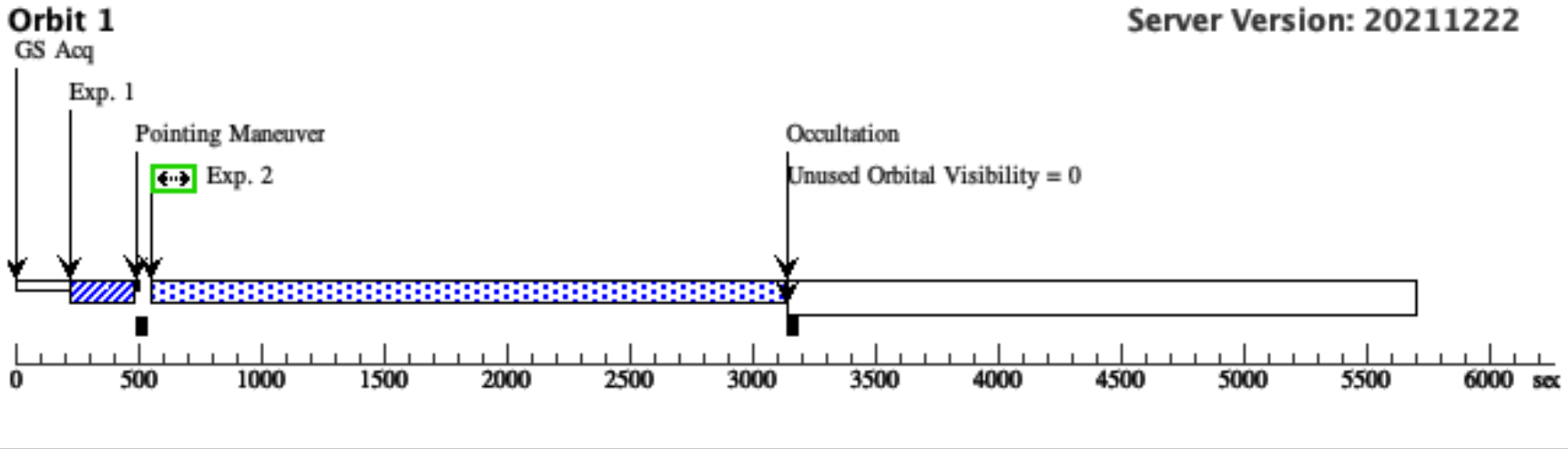
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SA3 Alt Name1: J101104.79-044220.9	RA: 10 11 4.7899 (152.7699579d) Dec: -04 42 20.96 (-4.70582d) Equinox: J2000		V=20.6 F225W = 18.0, F275W = 18.3, F336W = 18.8, F475W = 20.6, F814W = 21.1	Reference Frame: ICRS

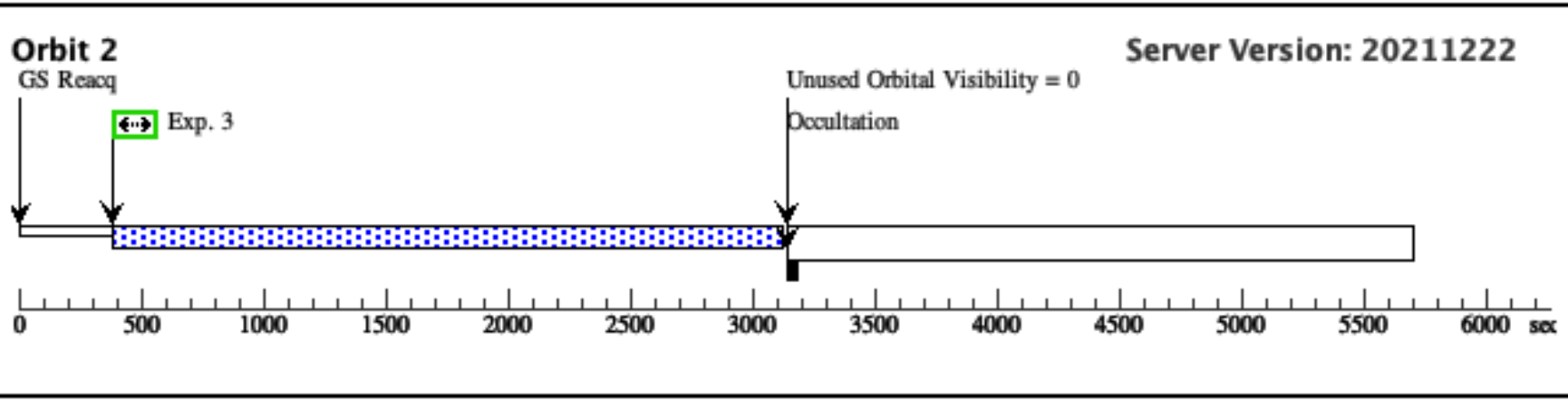
Comments:
Category=EXT-STAR
Description=[MAIN SEQUENCE O]
Extended=NO

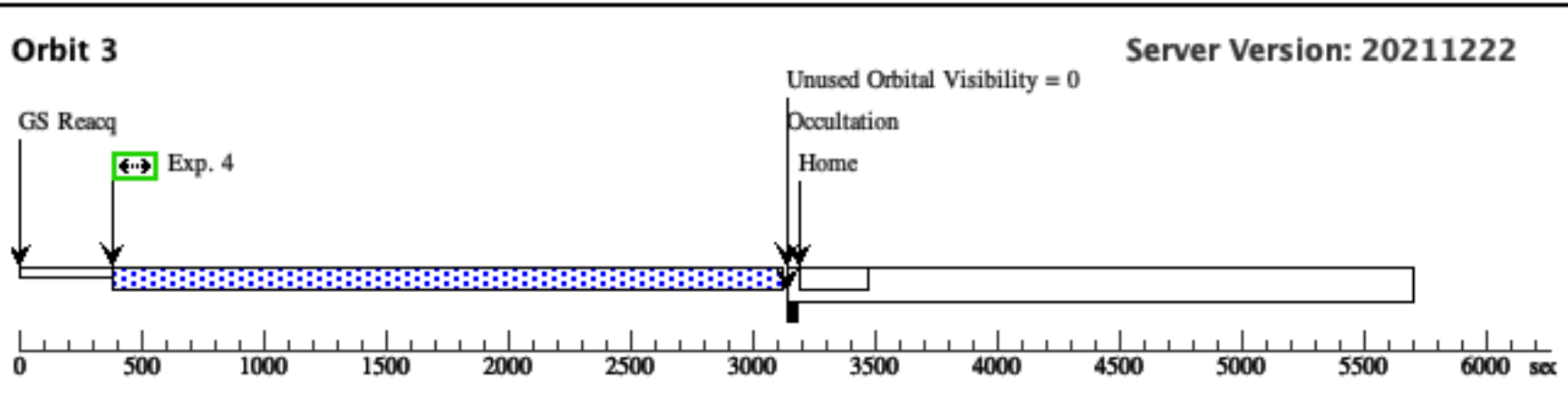
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ (COS.ta.1742873)	(1) SA3	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				14.3 Secs (14.3 Secs) *[==>]*	*[1]*
2	G160M-FPPOS2 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=2; FLASH=YES; SEGMENT=BOTH			2360 Secs (2360 Secs) *[==>]*	*[1]*
3	G160M-FPPOS3 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=3; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	*[2]*
4	G160M-FPPOS4 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=4; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	*[3]*

Orbit Structure







Visit

Proposal 16920, SA3-G160M (05) Tue Mar 29 15:00:20 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

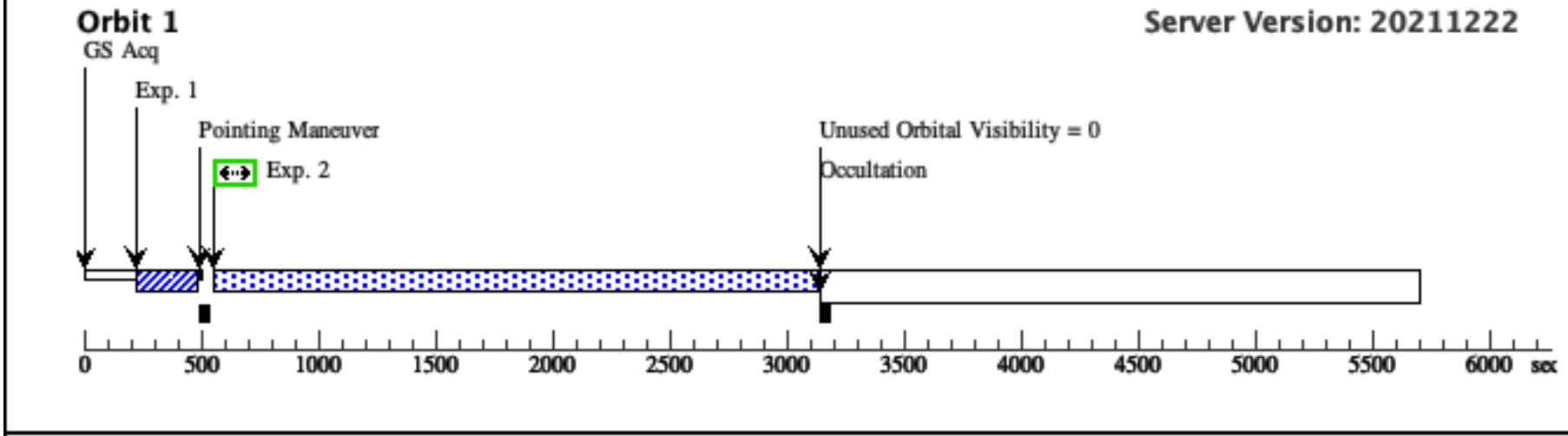
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SA3 Alt Name1: J101104.79-044220.9	RA: 10 11 4.7899 (152.7699579d) Dec: -04 42 20.96 (-4.70582d) Equinox: J2000		V=20.6 F225W = 18.0, F275W = 18.3, F336W = 18.8, F475W = 20.6, F814W = 21.1	Reference Frame: ICRS

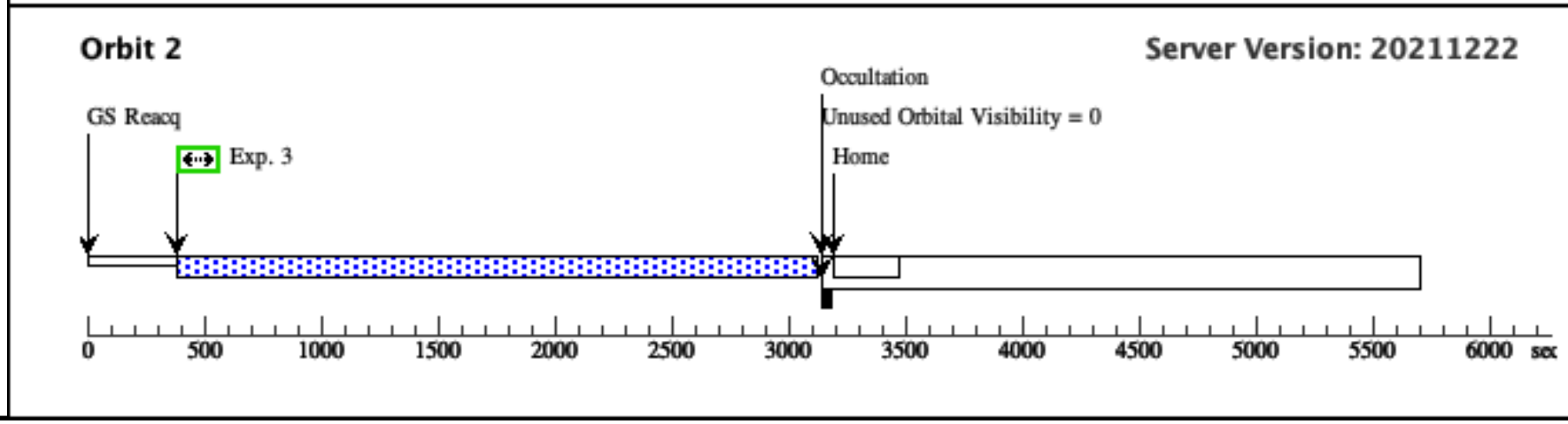
Comments:
Category=EXT-STAR
Description=[MAIN SEQUENCE O]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ (COS.ta.1742873)	(1) SA3	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				14.3 Secs (14.3 Secs) *[==>]*	***[1]***
2	G160M-FPPOS1 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=1; FLASH=YES; SEGMENT=BOTH			2360 Secs (2360 Secs) *[==>]*	***[1]***
3	G160M-FPPOS2 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=2; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	***[2]***

Orbit Structure





Visit

Proposal 16920, SA3-G160M (06) Tue Mar 29 15:00:20 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SA3 Alt Name1: J101104.79-044220.9	RA: 10 11 4.7899 (152.7699579d) Dec: -04 42 20.96 (-4.70582d) Equinox: J2000		V=20.6 F225W = 18.0, F275W = 18.3, F336W = 18.8, F475W = 20.6, F814W = 21.1	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[MAIN SEQUENCE O]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ (COS.ta.1742873)	(1) SA3	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				14.3 Secs (14.3 Secs) *[==>]*	*[1]*
2	G160M-FPPOS1 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=1; FLASH=YES; SEGMENT=BOTH			2360 Secs (2360 Secs) *[==>]*	*[1]*
3	G160M-FPPOS4 (COS.sp.1686149)	(1) SA3	COS/FUV, TIME-TAG, PSA	G160M 1600 A	BUFFER-TIME=10000; FP-POS=4; FLASH=YES; SEGMENT=BOTH			2686 Secs (2686 Secs) *[==>]*	*[2]*

Orbit Structure