17276 - A new radio pulsing white dwarf?

Cycle: 30, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
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Jaco Brink (CoI)	South African Astronomical Observatory

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) J191213.72-441045.1	COS/FUV COS/NUV	4	04-Aug-2023 12:00:19.0	yes
02	(1) J191213.72-441045.1	COS/FUV COS/NUV	4	04-Aug-2023 12:00:20.0	yes
03	(1) J191213.72-441045.1	COS/FUV COS/NUV	4	04-Aug-2023 12:00:21.0	yes
04	(1) J191213.72-441045.1	COS/FUV COS/NUV	1	04-Aug-2023 12:00:21.0	yes

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
05	(1) J191213.72-441045.1	COS/FUV COS/NUV	1	04-Aug-2023 12:00:22.0	yes

14 Total Orbits Used

ABSTRACT

In April this year, we have discovered a system showing strong optical pulses on a period of 5.3 minutes, during which the flux increases by up to a factor of four. Optical spectroscopy revealed a blue continuum added to the red spectrum of an M-type dwarf, with strong Balmer and neutral helium lines in emission. The radial velocity of the lines varies on a period of 4.03 hours, consistent with a photometric modulation observed on TESS data and clearly identifying the system as a compact binary. Perhaps most fascinating of all, the 5.3 minute pulses are also identified in radio. While radio pulses are reminiscent of neutron star or black hole binaries, the 5.3 min modulation is archetypical of the spin period of a strongly magnetic white dwarf. Only one other white dwarf binary is known to show this behaviour: the white dwarf pulsar AR Scorpii, in which the combination of a magnetic field and rapid rotation results in the acceleration of relativisitic particles that blast the inner hemisphere of the M-dwarf companion, akin to the well-known milli-second pulsars. We believe our system to be the first ever AR Sco twin, establishing white dwarf pulsars as a class. The ultimate proof of our hypothesis relies on the unambiguous identification of the white dwarf, which will be achieved through the detection of hydrogen absorption in the requested COS/G140L observations. This discovery will provide the first opportunity to test models proposed to explain the origin of AR Sco and shed light onto the evolution of close binaries.

OBSERVING DESCRIPTION

We require FUV spectroscopy of J1912 in TIME-TAG mode, which allows to re-bin the data in both time and wavelength. We will generate ultraviolet light curves and time-resolved spectra that we will bin both on the orbital period of the binary, and the spin period of the white dwarf. With these data in hand, we will (i) confirm the presence of a white dwarf in the system, (ii) measure the UV amplitude of the pulses, (iii) probe for the occurrence of flares, and (iv) probe for Zeeman splitting indicating a magnetic field.

For covering the FUV, we will use COS with the G140L grating centred at 1105 A, which provides flux-calibrated coverage between 1118 and 2150 A. This configuration provides us with good coverage of Lyman-alpha, where Zeeman splitting would be most evident, and of the H2 quasi-molecular absorption at 1600 A, which is particularly sensitive to temperature (Allard et al., 2004).

We used white dwarf models with the temperature estimate for AR Sco to calculate the required exposure time for our observations. To confirm the white dwarf, we require signal-to-noise ratio (SNR) of ~5 in the vicinity of the Lyman-alpha line, which according to the ETC requires ~34,800 sec. Overheads consist of guide star acquisition (6 min in the first orbit, 4 min for subsequent orbits), target acquisition (4 min in the first orbit only), and instrument overheads (5 min for the first orbit, 2 min for subsequent orbits). Our target has an orbital visibility of 55 min, so accounting for these overheads we require 12 orbits to reach the required SNR in the FUV. Our request can be broken into separate smaller visits if necessary.

J1912 is the brightest object in a 25 arcsec radius, and even during the strongest detected flares its brightness does not surpass V~16, well below the brightness limit of the COS.

Visit

Proposal 17276, First visit (01), completed Fri Aug 04 16:00:22 GMT 2023

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

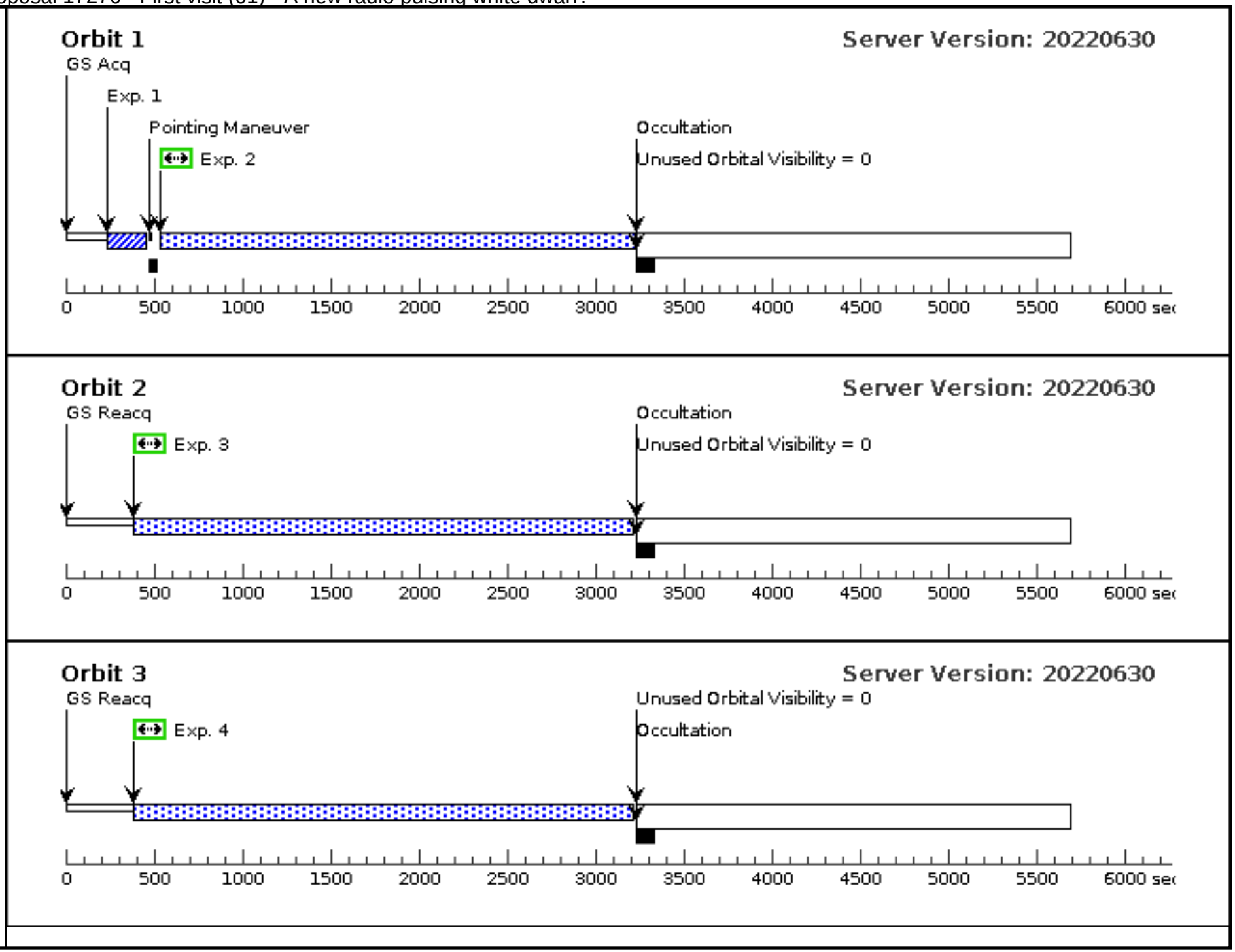
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	J191213.72-441045.1	RA: 19 12 13.7198 (288.0571658d) Dec: -44 10 45.08 (-44.17919d) Equinox: J2000	Proper Motion RA: -16.61 mas/yr Proper Motion Dec: -11.01 mas/yr Epoch of Position: 2000	V=16.86+/-0.92	Reference Frame: ICRS

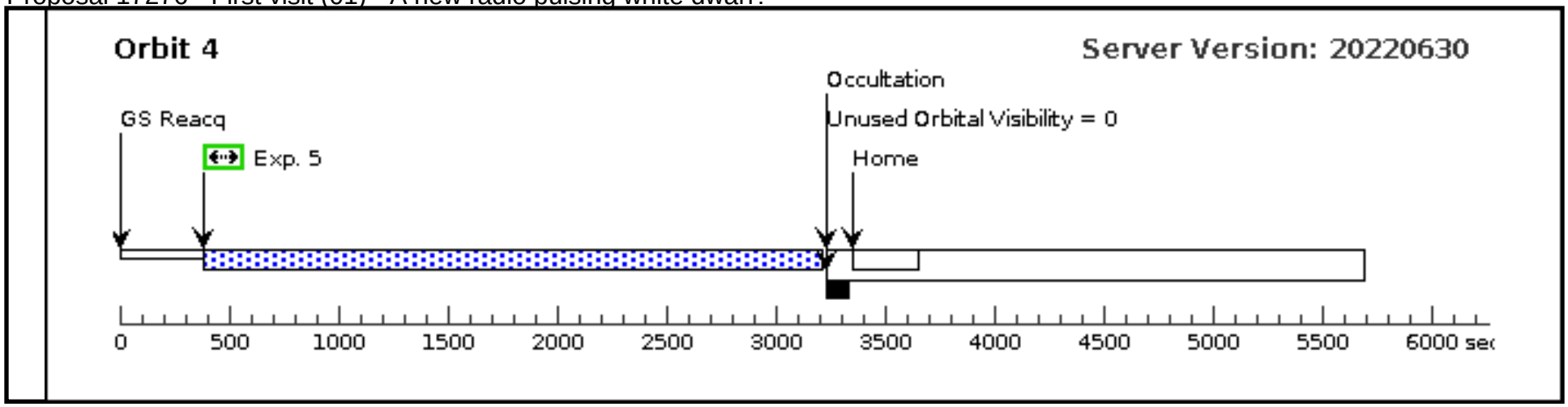
Comments:
Category=STAR
Description=[INTERACTING BINARY, INTERMEDIATE POLAR, REGULAR VARIABLE]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.ta.1836155)	(1) J191213.72-441045.1	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				5 Secs (5 Secs) *[==>]*	*[1]*
2	Science (COS.sp.1836328)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2508; FP-POS=1			2508 Secs (2508 Secs) *[==>]*	*[1]*
3	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=2			2782 Secs (2782 Secs) *[==>]*	*[2]*
4	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=3			2782 Secs (2782 Secs) *[==>]*	*[3]*
5	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=4			2782 Secs (2782 Secs) *[==>]*	*[4]*

Orbit Structure




Orbit 4
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Occultation
GS Reacq
Unused Orbital Visibility = 0
Exp. 5
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Visit

Proposal 17276, Second visit (02), failed Fri Aug 04 16:00:22 GMT 2023

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

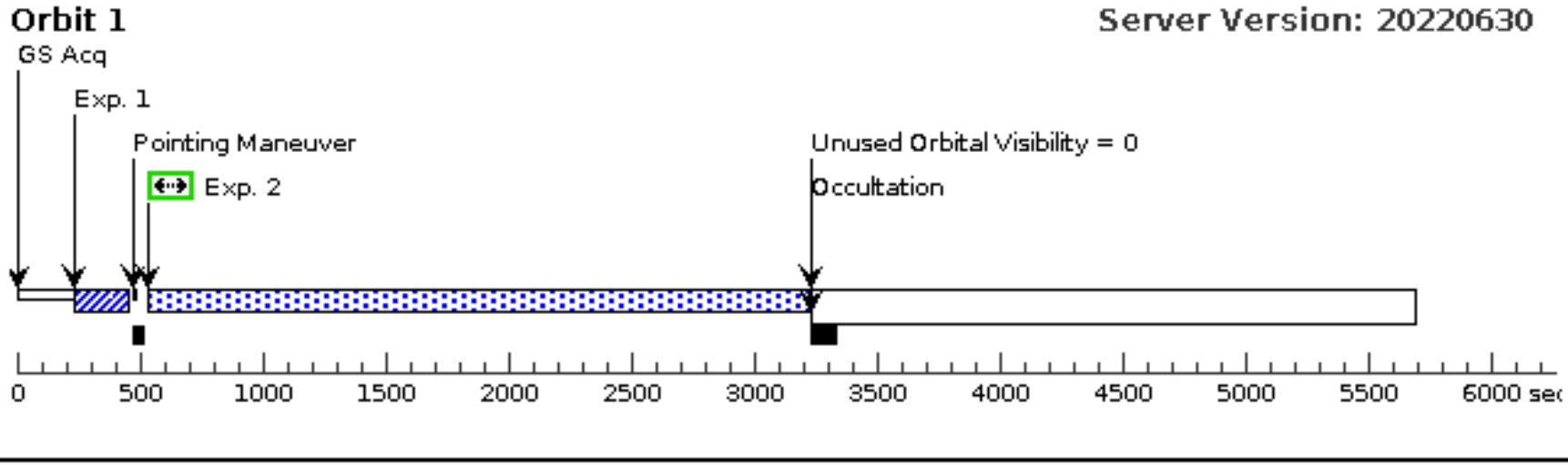
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	J191213.72-441045.1	RA: 19 12 13.7198 (288.0571658d) Dec: -44 10 45.08 (-44.17919d) Equinox: J2000	Proper Motion RA: -16.61 mas/yr Proper Motion Dec: -11.01 mas/yr Epoch of Position: 2000	V=16.86+/-0.92	Reference Frame: ICRS

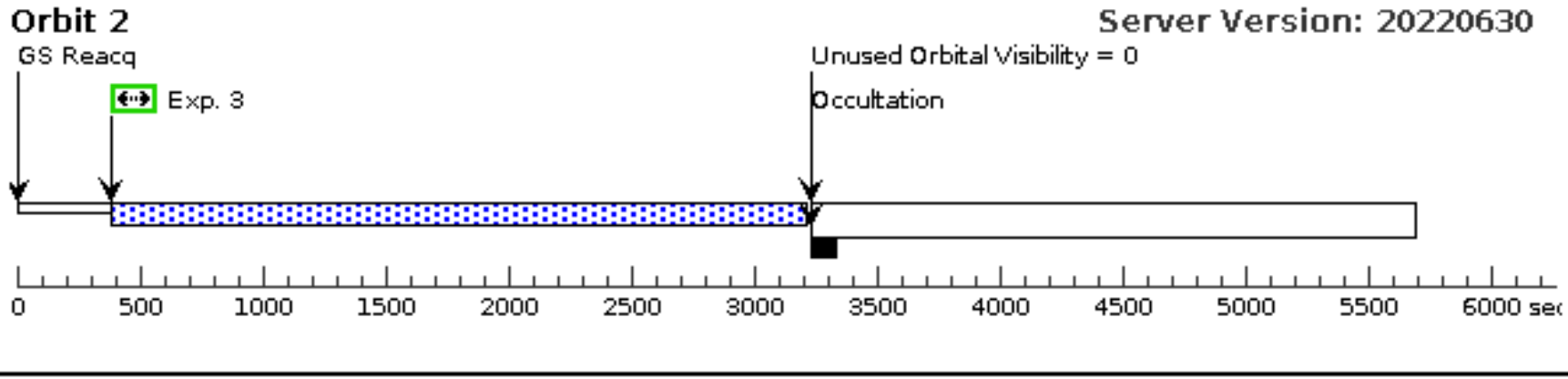
Comments:
Category=STAR
Description=[INTERACTING BINARY, INTERMEDIATE POLAR, REGULAR VARIABLE]
Extended=NO

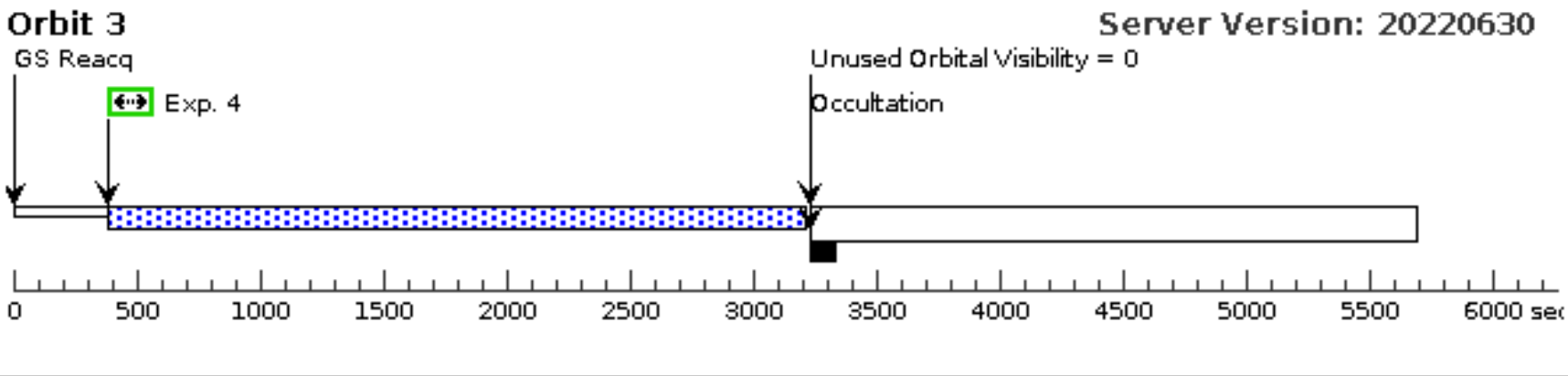
Exposures

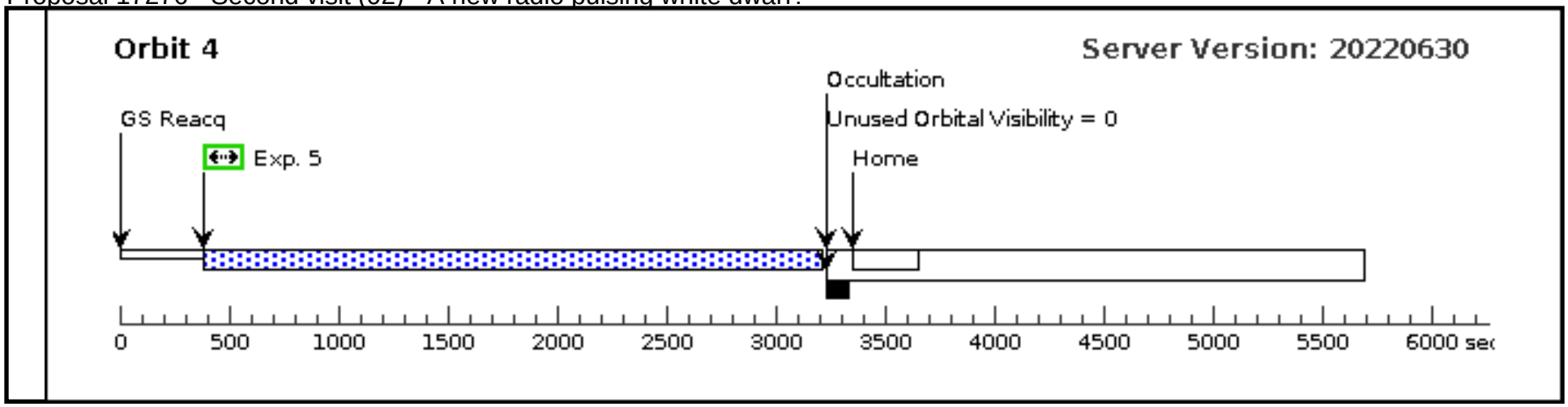
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.ta.1836155)	(1) J191213.72-441045.1	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				5 Secs (5 Secs) *[==>]*	*[1]*
2	Science (COS.sp.1836328)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2508; FP-POS=1			2508 Secs (2508 Secs) *[==>]*	*[1]*
3	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=2			2782 Secs (2782 Secs) *[==>]*	*[2]*
4	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=3			2782 Secs (2782 Secs) *[==>]*	*[3]*
5	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=4			2782 Secs (2782 Secs) *[==>]*	*[4]*

Orbit Structure








Orbit 4
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Exp. 5
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Visit

Proposal 17276, Third visit (03), failed Fri Aug 04 16:00:22 GMT 2023

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

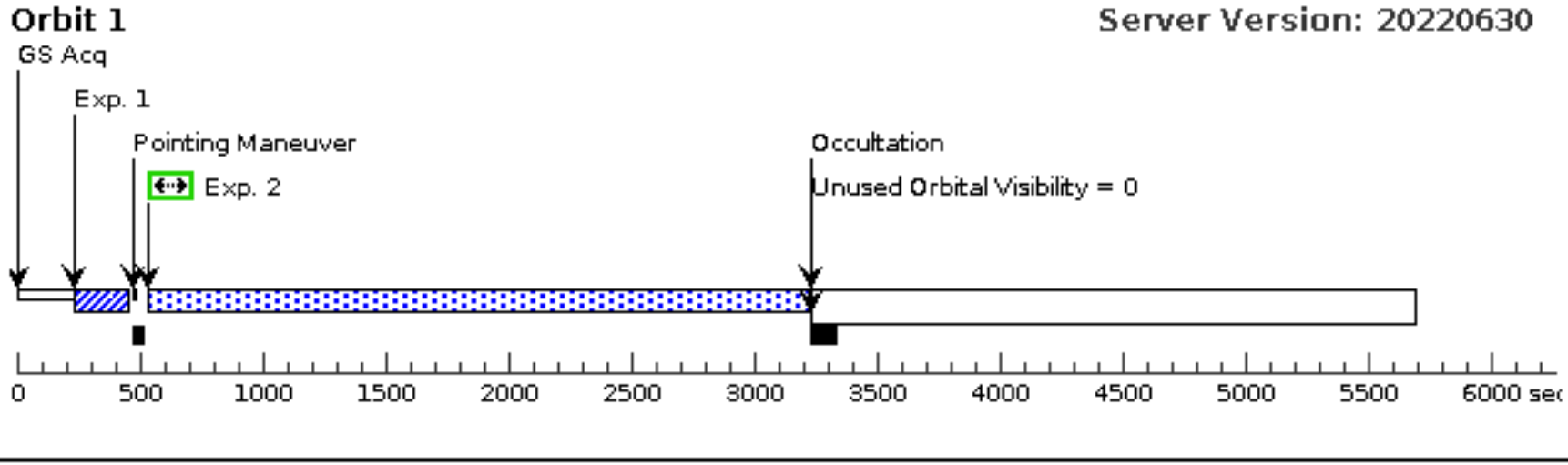
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	J191213.72-441045.1	RA: 19 12 13.7198 (288.0571658d) Dec: -44 10 45.08 (-44.17919d) Equinox: J2000	Proper Motion RA: -16.61 mas/yr Proper Motion Dec: -11.01 mas/yr Epoch of Position: 2000	V=16.86+/-0.92	Reference Frame: ICRS

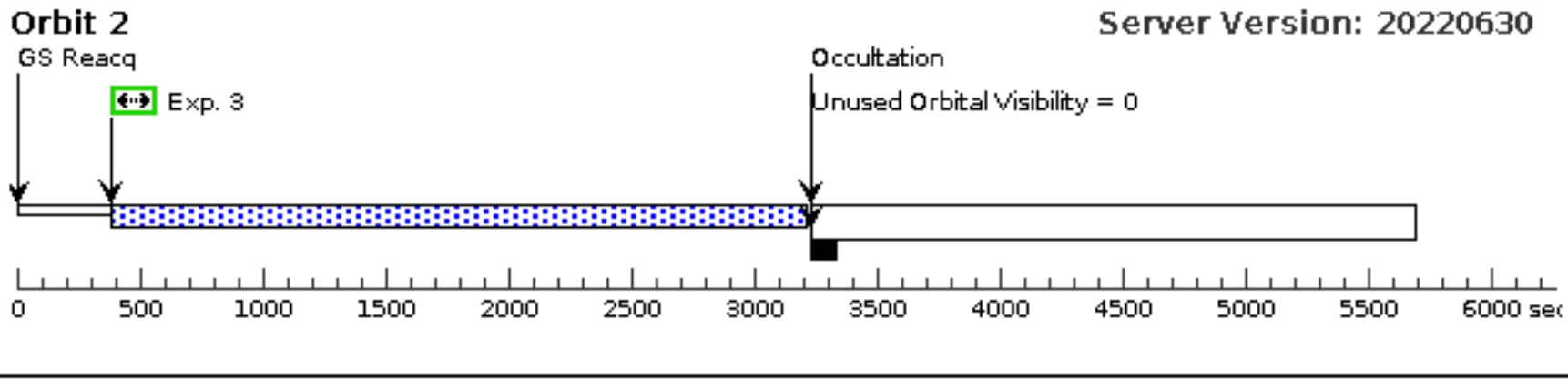
Comments:
Category=STAR
Description=[INTERACTING BINARY, INTERMEDIATE POLAR, REGULAR VARIABLE]
Extended=NO

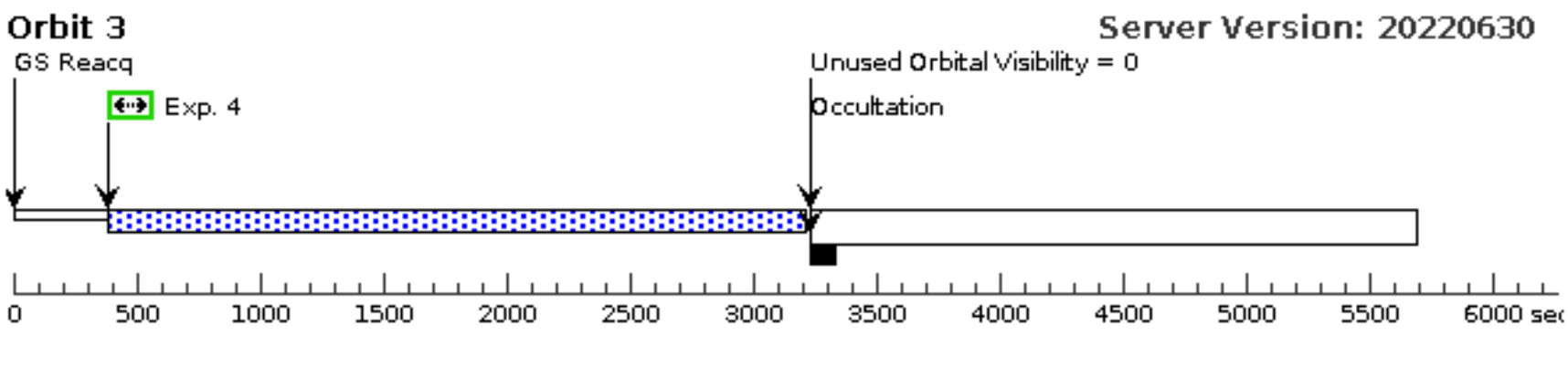
Exposures

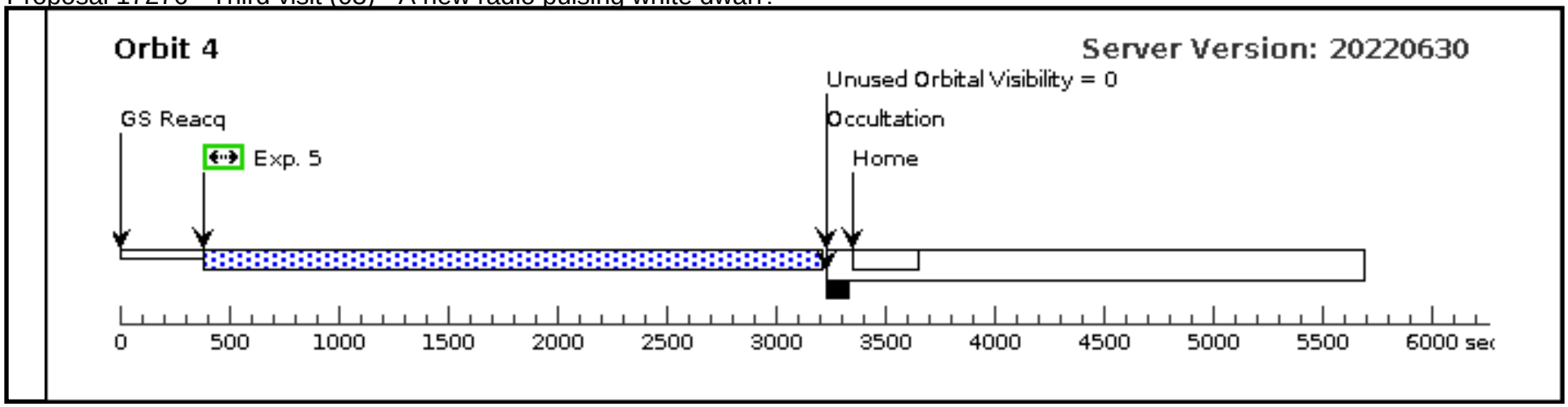
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.ta.1836155)	(1) J191213.72-441045.1	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				5 Secs (5 Secs) *[==>]*	***[1]***
2	Science (COS.sp.1836328)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2508; FP-POS=1			2508 Secs (2508 Secs) *[==>]*	***[1]***
3	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=2			2782 Secs (2782 Secs) *[==>]*	***[2]***
4	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=3			2782 Secs (2782 Secs) *[==>]*	***[3]***
5	Science (COS.sp.1836329)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2782; FP-POS=4			2782 Secs (2782 Secs) *[==>]*	***[4]***

Orbit Structure








Orbit 4
Server Version: 20220630
Unused Orbital Visibility = 0
GS Reacq
Occultation
Exp. 5
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Visit

Proposal 17276, Second visit repeat (04) Fri Aug 04 16:00:22 GMT 2023

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 0.16811989 D AND ZERO-PHASE HJD2459784.98230

Diagnostics

(Second visit repeat (04)) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave. See the COS Instrument Handbook for exceptions that may apply to observations with G130M/1291 or G160M.

Fixed Targets

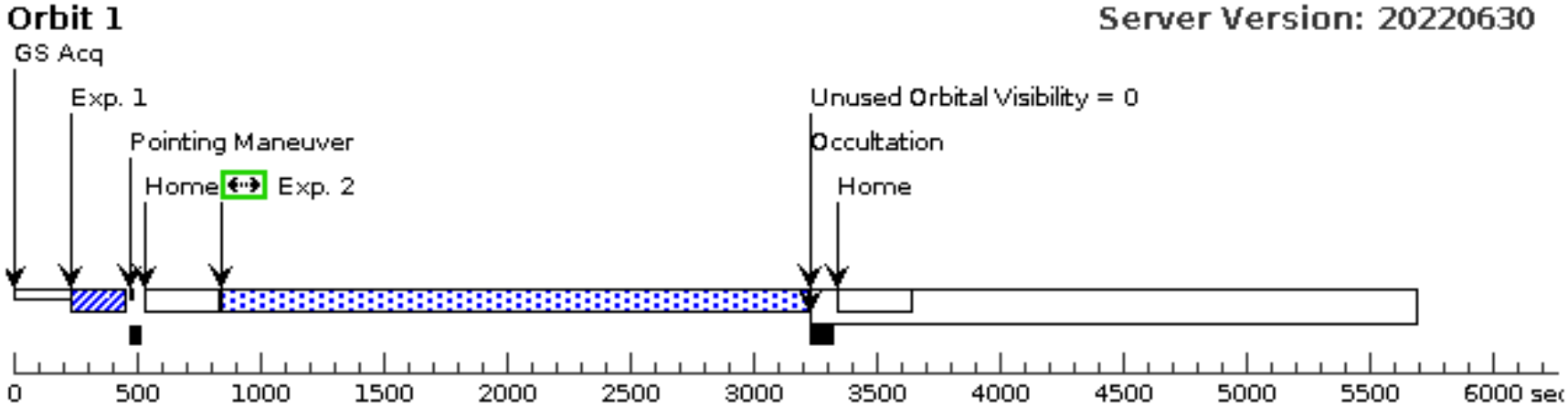
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	J191213.72-441045.1	RA: 19 12 13.7198 (288.0571658d) Dec: -44 10 45.08 (-44.17919d) Equinox: J2000	Proper Motion RA: -16.61 mas/yr Proper Motion Dec: -11.01 mas/yr Epoch of Position: 2000	V=16.86+/-0.92	Reference Frame: ICRS

Comments:
Category=STAR
Description=[INTERACTING BINARY, INTERMEDIATE POLAR, REGULAR VARIABLE]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.ta.1836155)	(1) J191213.72-441045.1	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				5 Secs (5 Secs) *[==>]*	*[1]*
2	Science (COS.sp.1836328)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2508; FP-POS=1	PHASE 0.45 TO 0.7		2508 Secs (2148 Secs) *[==>2148.0 Secs]*	*[1]*

Orbit Structure



Visit

Proposal 17276, Third visit repeat (05) Fri Aug 04 16:00:22 GMT 2023

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 0.16811989 D AND ZERO-PHASE HJD2459784.98230

Diagnostics

(Third visit repeat (05)) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave. See the COS Instrument Handbook for exceptions that may apply to observations with G130M/1291 or G160M.

Fixed Targets

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Comments:
Category=STAR
Description=[INTERACTING BINARY, INTERMEDIATE POLAR, REGULAR VARIABLE]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.ta.1836155)	(1) J191213.72-441045.1	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				5 Secs (5 Secs) *[==>]*	*[1]*
2	Science (COS.sp.1836328)	(1) J191213.72-441045.1	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2508; FP-POS=1	PHASE 0.45 TO 0.7		2508 Secs (2148 Secs) *[==>2148.0 Secs]*	*[1]*

Orbit Structure