17613 - Continuing the Legacy of AU Mic: Simultaneous FUV and NIR Observations of AU Mic b

Cycle: 31, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Dr. Adina Feinstein (PI) (Contact)	**Michigan State University**
Dr. Luis Welbanks (CoI)	Arizona State University
Dr. Eva-Maria Ahrer (CoI) (ESA Member)	Max Planck Institute for Astronomy
Dr. Lili Alderson (CoI)	Cornell University
Prof. Jacob L. Bean (CoI)	University of Chicago
Dr. Zach K. Berta-Thompson (CoI)	University of Colorado at Boulder
Alastair Claringbold (CoI) (ESA Member)	University of Warwick
Prof. Kevin France (CoI)	University of Colorado at Boulder
Dr. Nikole Lewis (CoI)	Cornell University
Dr. Andrew Withycombe Mann (CoI)	University of North Carolina at Chapel Hill
Dr. Annabella Meech (CoI)	Smithsonian Institution Astrophysical Observatory
Dr. Catriona Anne Murray (CoI)	University of Colorado at Boulder
Dr. Benjamin Rackham (CoI)	Massachusetts Institute of Technology
Dr. Paul Rimmer (CoI) (ESA Member)	University of Cambridge
Dr. Keighley Elizabeth Rockcliffe (CoI)	University of Maryland, Baltimore County
Dr. Everett Schlawin (CoI)	University of Arizona
Darryl Seligman (CoI)	Michigan State University
Pa Chia Thao (CoI)	University of North Carolina at Chapel Hill
Dr. Hannah Wakeford (CoI) (ESA Member)	University of Bristol
Prof. Peter J. Wheatley (CoI) (ESA Member)	University of Warwick

Name	*Institution*
Michael Zhang (CoI)	University of Chicago
Prof. Monika Lendl (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Dr. Girish M. Duvvuri (CoI)	Vanderbilt University
Dr. David John Wilson (CoI)	University of Colorado at Boulder

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) V-AU-MIC	COS/FUV COS/NUV	6	21-Apr-2025 15:00:12.0	yes
02	(1) V-AU-MIC	COS/FUV COS/NUV	6	21-Apr-2025 15:00:13.0	yes
03	(1) V-AU-MIC	COS/FUV COS/NUV	6	21-Apr-2025 15:00:14.0	yes
04	(1) V-AU-MIC	COS/FUV COS/NUV	6	21-Apr-2025 15:00:15.0	yes

24 Total Orbits Used

ABSTRACT

The 23 Myr M star AU Mic and its transiting planets are an ideal laboratory for understanding the impact of stellar activity on young exoplanet atmospheres. Young planetary systems offer a unique advantage in that their spectral signatures are representative of primordial formation conditions. This is significantly advantageous when compared with more evolved planets which have experienced significant stellar irradiation, processing and pollution. The formation mechanism and subsequent evolution of massive, short-period planets is not currently well understood. For example, these planets may have formed at large distances and migrated inwards or alternatively formed in situ. Here, we propose to obtain spectra during 4 transits of AU Mic b, the innermost Neptune-sized planet in the system (Teq = 820K), with NIRCam F322W2/F444W (2.4 - 5 micron). Our primary objective is to measure atmospheric C/O and metallicity to constrain the formation location of the planet.

We propose for simultaneous JWST + HST observations. The chemistry in the atmosphere of AU Mic b will be dictated by the environmental ultraviolet flux. Because AU Mic is both young and a flare-active star, we require FUV observations to (i) identify and remove stellar flares from our transmission spectrum and (ii) characterize the FUV environment, which will be crucial for interpreting our planet spectrum. These observations will

also provide unique FUV - NIR measurements of flare events, furthering our understanding of stellar magnetism. These spectra will provide an important legacy for understanding young stars, planetary atmospheres, and combining NIR + FUV to mitigate stellar contamination.

OBSERVING DESCRIPTION

We will observe four transits of AU Mic b simultaneously with JWST in order to monitor for stellar flares which are likely to occur during these observations. We will use the COS G130M setting with CENWAVE=1222 angstroms. This provides coverage from approximately 1060 - 1360 angstroms with a detector gap from 1210-1225 angstroms. This setting includes several emission lines which will be used to identify and characterize stellar flares (e.g. C III at 1175.95 Angstrom and Si III at 1294.55 Angstrom). The same COS setting will be used for all observations. This observing mode and setup have been used in previously successful HST programs (e.g. HST GO 16164).

AU Mic is visible for 3000 seconds during an HST orbit. Assuming a total exposure time of 3000 seconds, we expect to achieve a S/N of 75 - 100 in the C III lines. Our observations must occur during transits of AU Mic b, which has an orbital period of 8.46321 days and a transit duration of 3.5 hours. According to the APT visit planner, there are ~20 possible transits visible during Cycle 32 and JWST Cycle 3, during which our observations should be scheduled. This should be feasible to schedule our simultaneous observations. AU Mic b experiences transit timing variations. We are actively monitoring this system to account for these variations. The uncertainty on the period is 0.00004 days. The current uncertainty on the transit mid-point is 0.0007 days.

In order to obtain the longest out-of-transit baseline for each transit, we will stagger the out-of-transit observations for each visit in the following way: for 2 out of 3 transits we will obtain 2 pre-transit exposures and for 1 out of 3 transits we will obtain 2 post-transit exposures. Each transit will have 3 in-transit exposures. We believe this strategy is optimal so that the out-of-transit baseline extends as far as possible from ingress or egress, minimizing the possibility of a highly extended atmosphere creating pre- or post-transit absorption that could
skew the in-transit absorption depths. With this strategy in mind, each visit must be scheduled no earlier than planetary orbital phase 0.97 and no later than 0.99.

AU Mic is a pre-main sequence M-star with effective temperature T=3700+-100 K and must be considered under the Bright Object Protection Considerations for M Dwarf Flare events (Osten 2017). It exhibits flares with energy <= 10^30 ergs twice an hour (Feinstein et al. 2022). This can be compared to the active flare star AD Leo which experiences a flare with the same energy 5 times per day. From three archival visits to AU Mic, the star did not exhibit a flare with energy > 10^30 ergs, and thus is unlikely to exhibit a superflare during these proposed observations. Our selected COS configuration does not include the strongest FUV lines (e.g. Ly-alpha) which would otherwise cause damage to the detector. All emission line

fluxes in our configuration are within the safe range for active M dwarfs.

Visit

Proposal 17613, Visit 01, implementation Mon Apr 21 19:00:15 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: SCHED 100%; Period 8.46314280 D AND ZERO-PHASE HJD2460200.7339

Diagnostics

(Visit 01) 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.

(Visit 01) Warning (Orbit Planner): COS EXPOSURE TIME ROUNDED DOWN TO NEAREST 0.1 SECONDS

(Visit 01) Warning (Orbit Planner): COS EXPOSURE TIME ROUNDED DOWN TO NEAREST 0.1 SECONDS

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-AU-MIC	RA: 20 45 9.8729 (311.2911371d) Dec: -31 20 32.82 (-31.34245d) Equinox: J2000	Proper Motion RA: 0.02196719120353366 sec of time/yr Proper Motion Dec: -0.35989499999686814 arcsec/yr Epoch of Position: 2015.5	V=8.627	Reference Frame: ICRS

Comments: This object was generated by the target selector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, EXTRA-SOLAR PLANETARY SYSTEM, PRE-MAIN SEQUENCE STAR]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(1452138)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM	PHASE .96 TO .98		3.3 Secs (3.3 Secs) *[==>]*	*[1]*
2	(1452139)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5; CENTER=FLUX-WT-FLR			2.8 Secs (2.8 Secs) *[==>]*	*[1]*
3	(1448377)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[1]*
4	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	FP-POS=4; BUFFER-TIME=1000			2015 Secs (2015 Secs) *[==>]*	*[2]*
5	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[3]*
6	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[4]*
7	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[5]*
8	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[6]*

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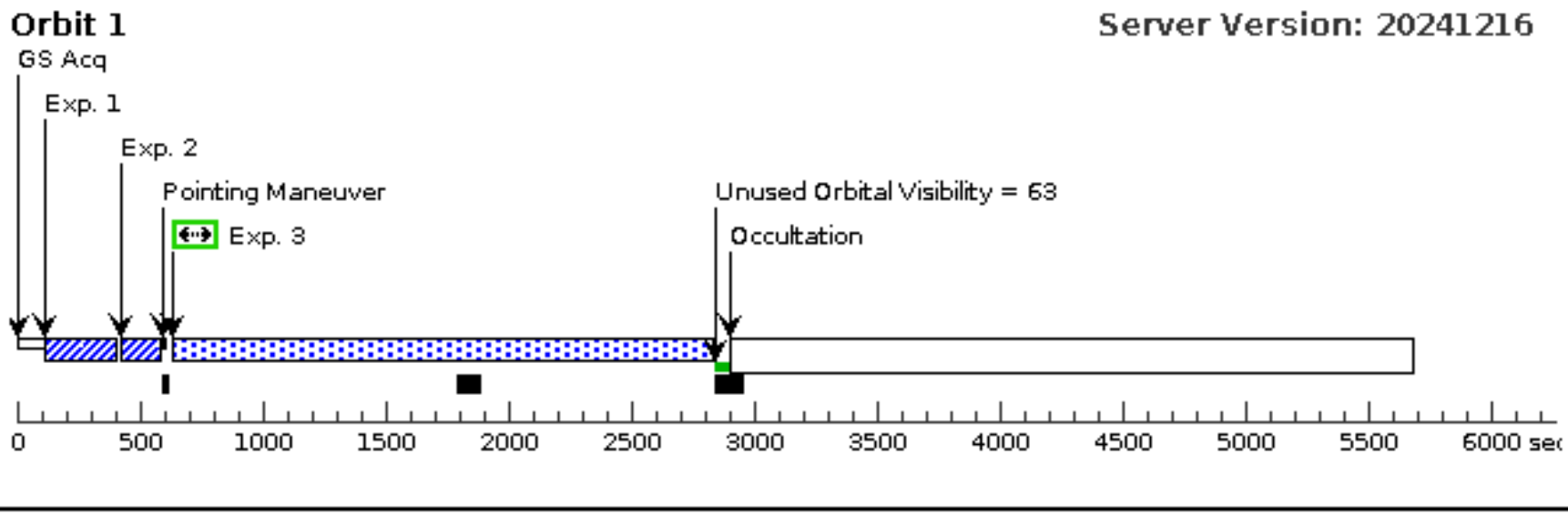

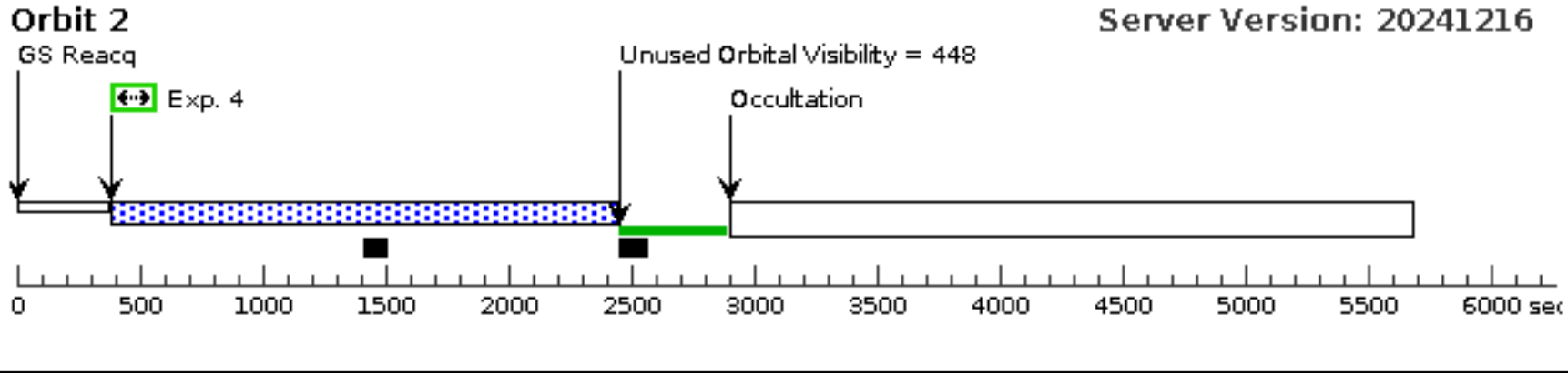

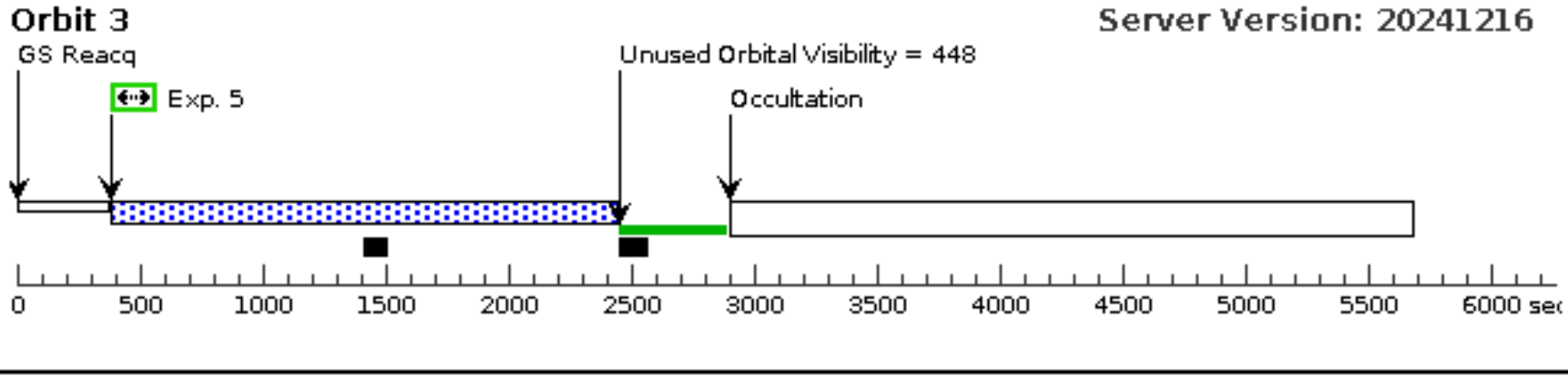
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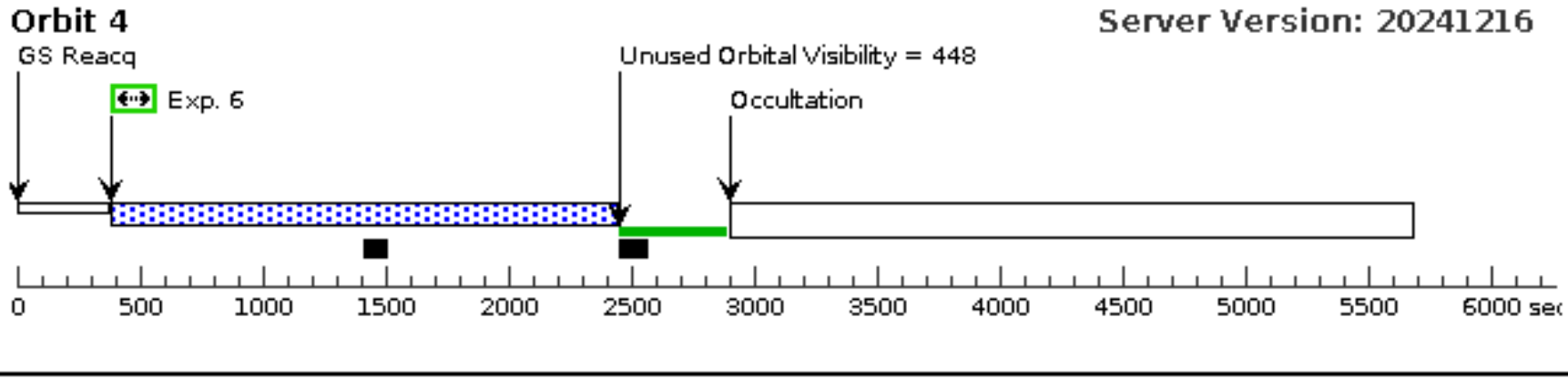
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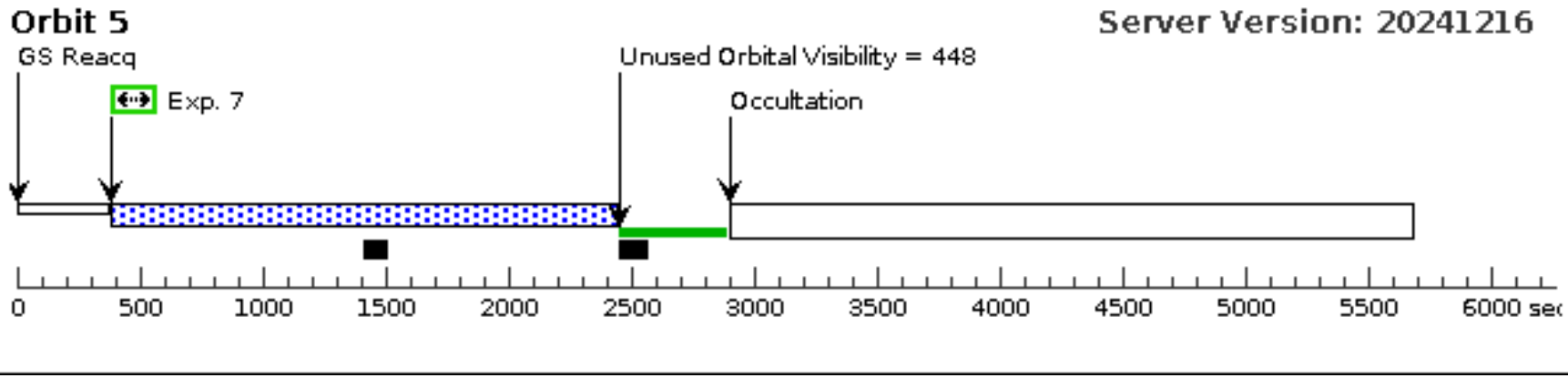
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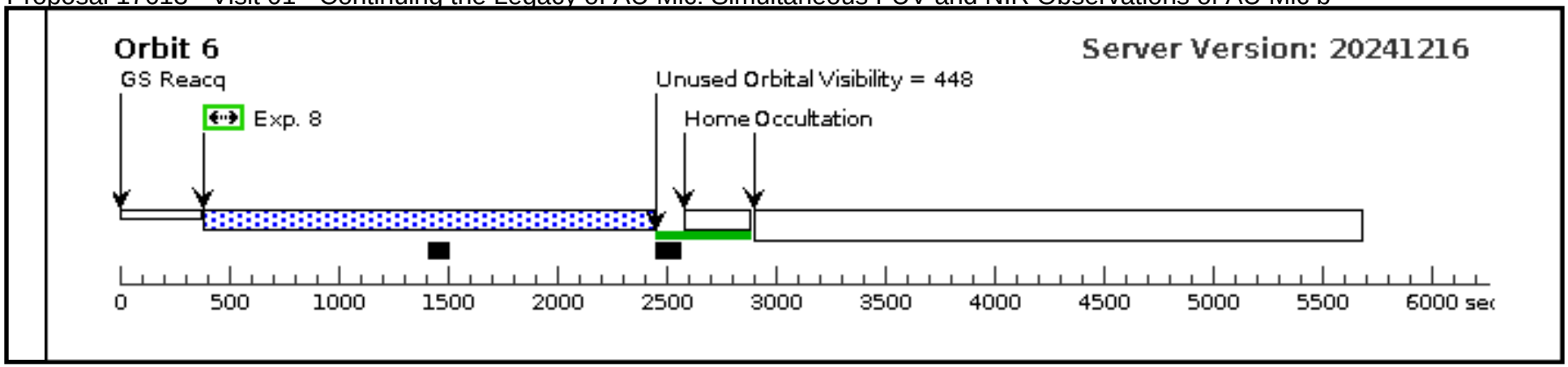
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Visit

Proposal 17613, Visit 02, implementation Mon Apr 21 19:00:15 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: SCHED 100%; Period 8.46314280 D AND ZERO-PHASE HJD2460200.7339

Diagnostics

(Visit 02) 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.

(Visit 02) Warning (Orbit Planner): COS EXPOSURE TIME ROUNDED DOWN TO NEAREST 0.1 SECONDS

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Fixed Targets

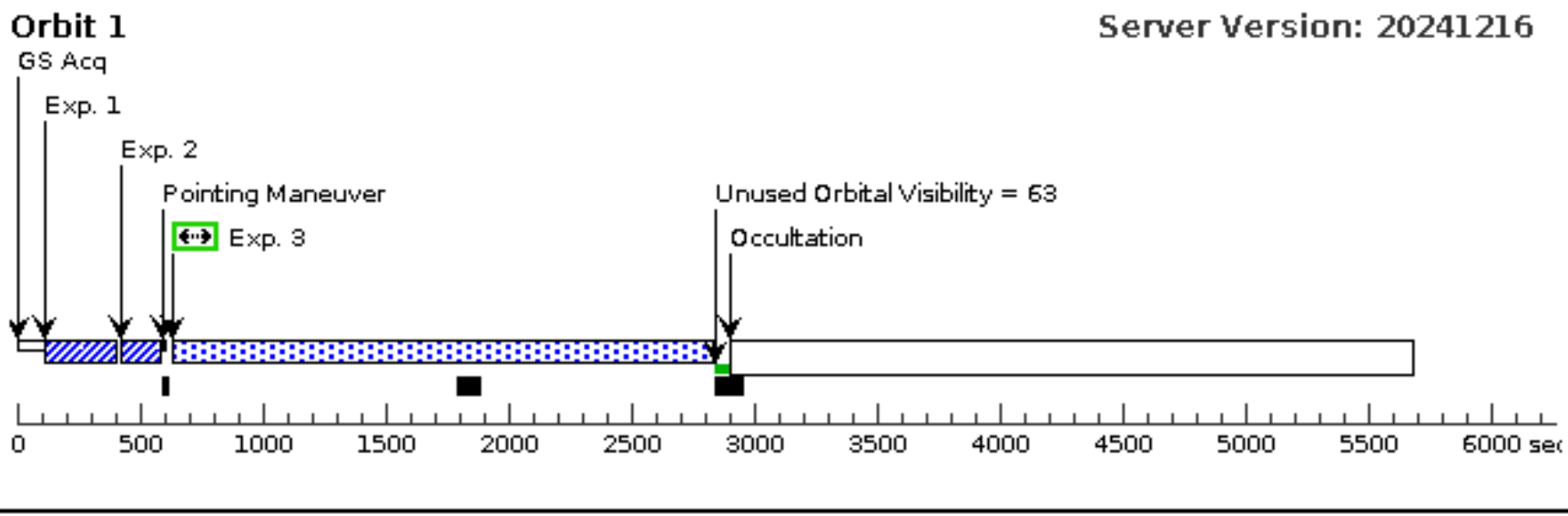
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-AU-MIC	RA: 20 45 9.8729 (311.2911371d) Dec: -31 20 32.82 (-31.34245d) Equinox: J2000	Proper Motion RA: 0.02196719120353366 sec of time/yr Proper Motion Dec: -0.35989499999686814 arcsec/yr Epoch of Position: 2015.5	V=8.627	Reference Frame: ICRS

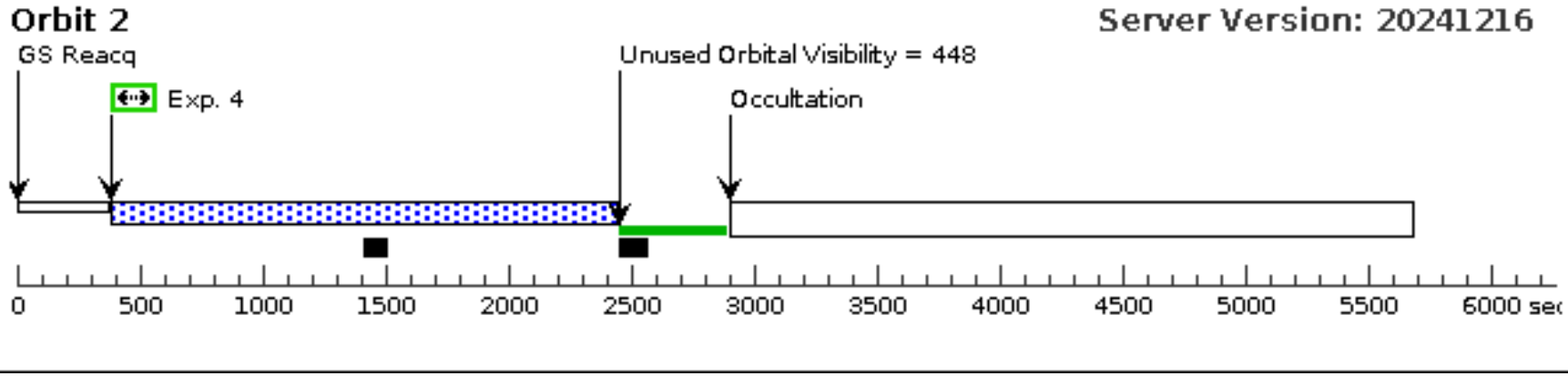
Comments: This object was generated by the target selector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, EXTRA-SOLAR PLANETARY SYSTEM, PRE-MAIN SEQUENCE STAR]
Extended=NO

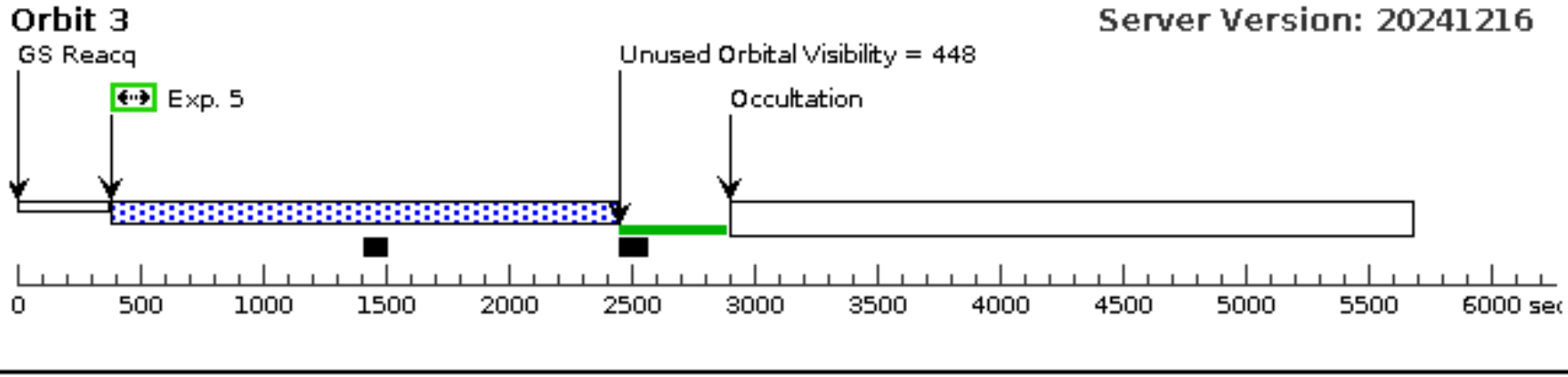
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(1452138)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM	PHASE .96 TO .98		3.3 Secs (3.3 Secs) *[==>]*	*[1]*
2	(1452139)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5; CENTER=FLUX-WT-FLR			2.8 Secs (2.8 Secs) *[==>]*	*[1]*
3	(1448377)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[1]*
4	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	FP-POS=4; BUFFER-TIME=1000			2015 Secs (2015 Secs) *[==>]*	*[2]*
5	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[3]*
6	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[4]*
7	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[5]*
8	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[6]*

Orbit Structure



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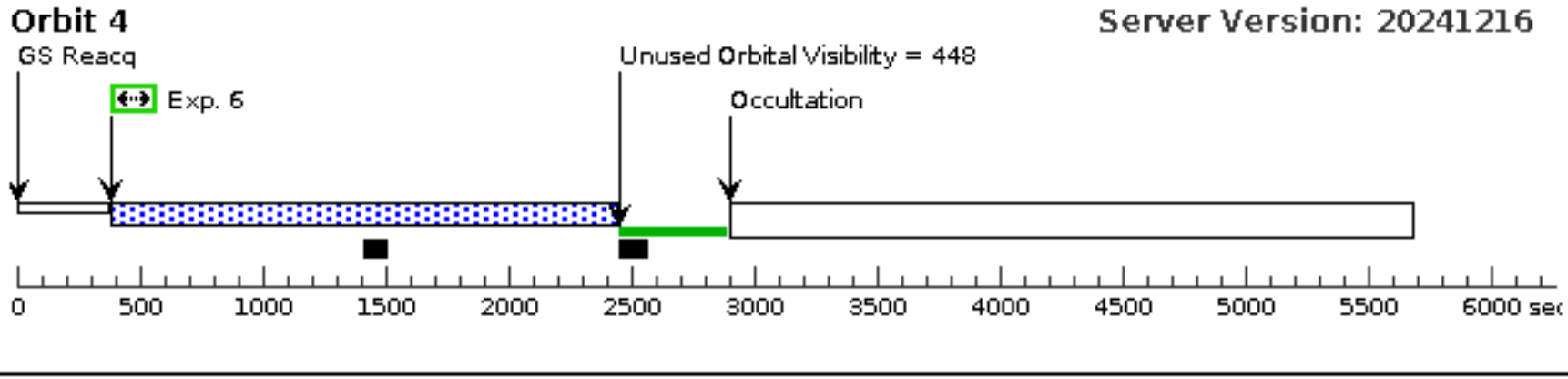
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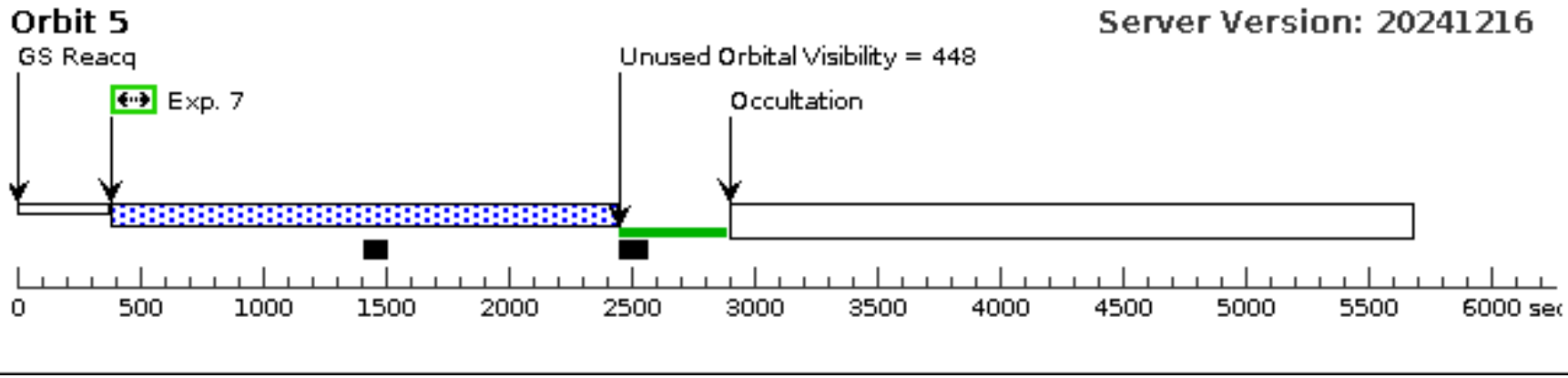
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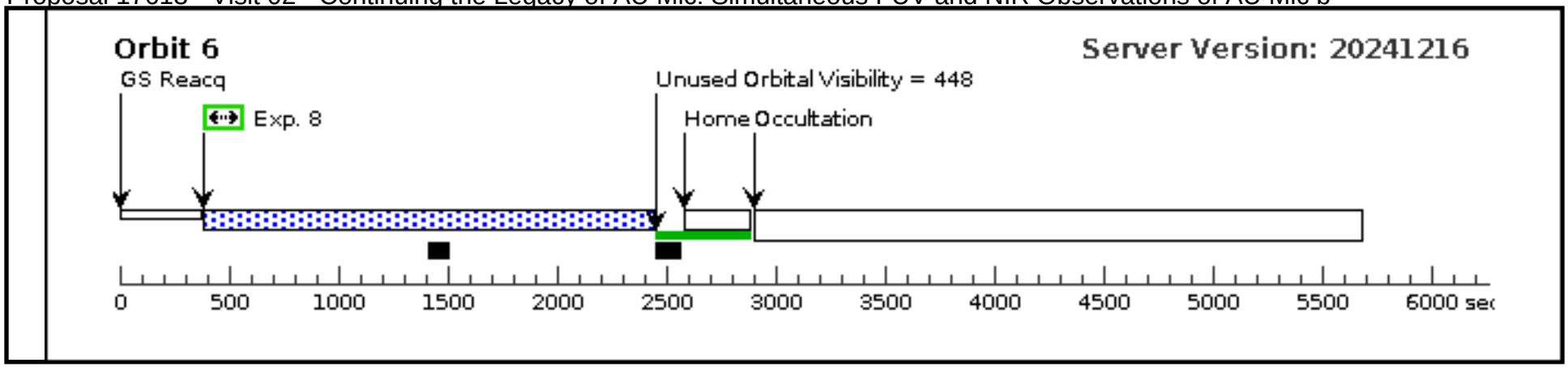
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Visit

Proposal 17613, Visit 03, implementation Mon Apr 21 19:00:16 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: SCHED 100%; Period 8.46314280 D AND ZERO-PHASE HJD2460200.7339

Diagnostics

(Visit 03) 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.

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Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
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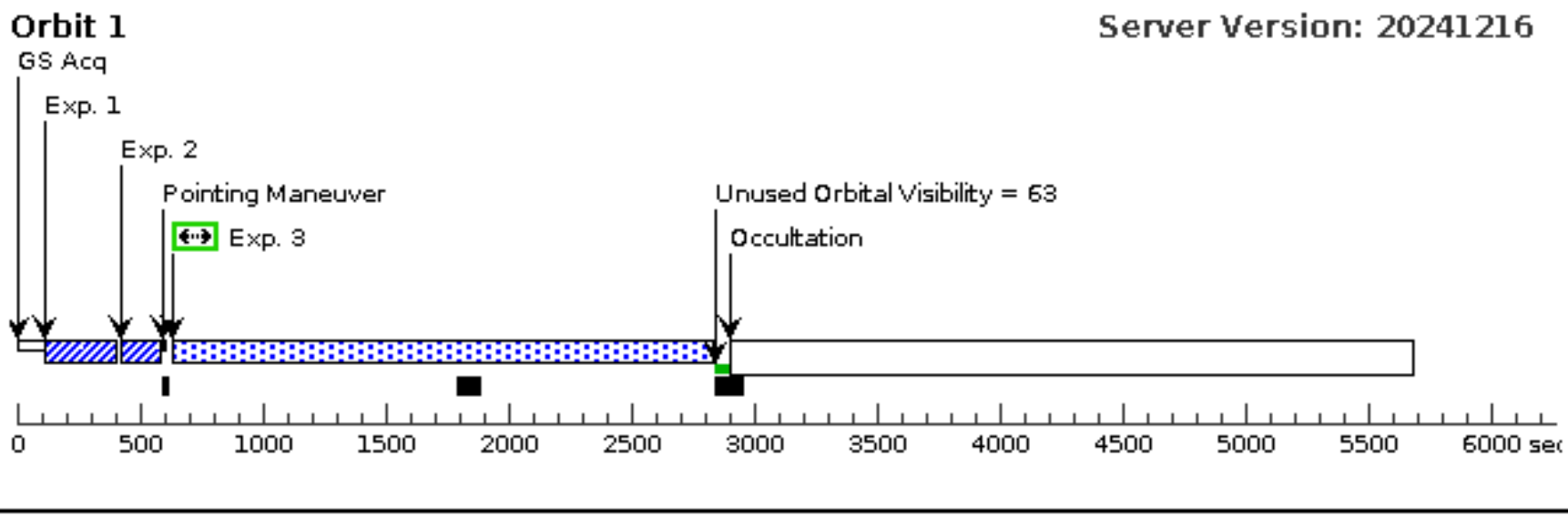
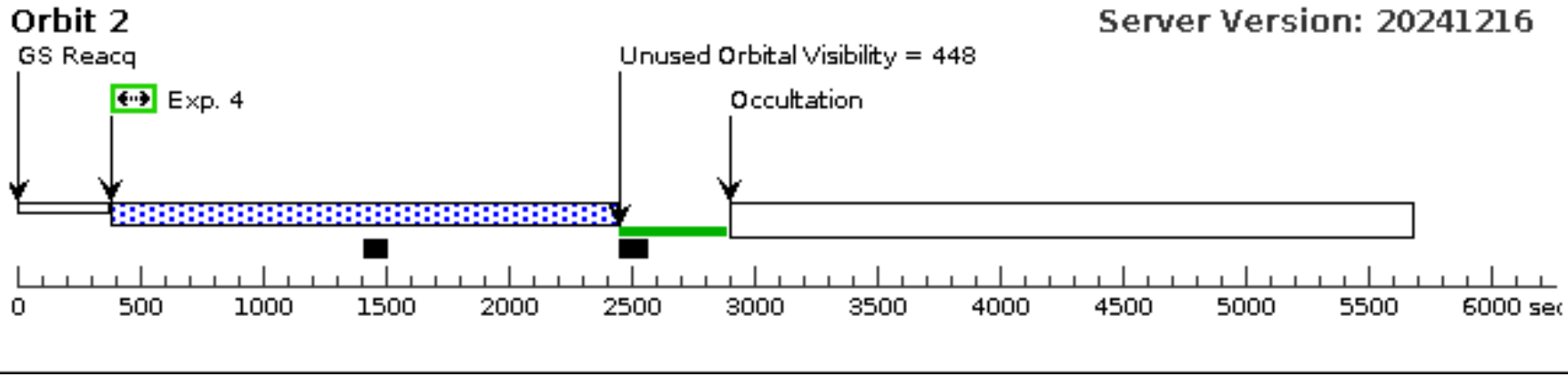
Extended=NO

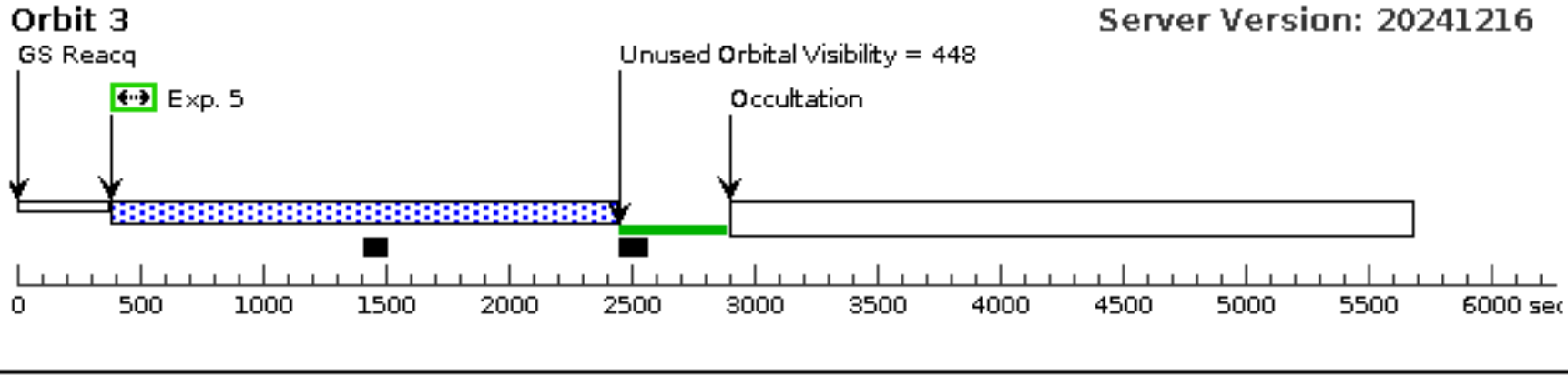
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(1452138)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM	PHASE 0.935 TO 0.98		3.3 Secs (3.3 Secs) *[==>]*	*[1]*
2	(1452139)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5; CENTER=FLUX-WT-FLR			2.8 Secs (2.8 Secs) *[==>]*	*[1]*
3	(1448377)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[1]*
4	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	FP-POS=4; BUFFER-TIME=1000			2015 Secs (2015 Secs) *[==>]*	*[2]*
5	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[3]*
6	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[4]*
7	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[5]*
8	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[6]*

Orbit Structure



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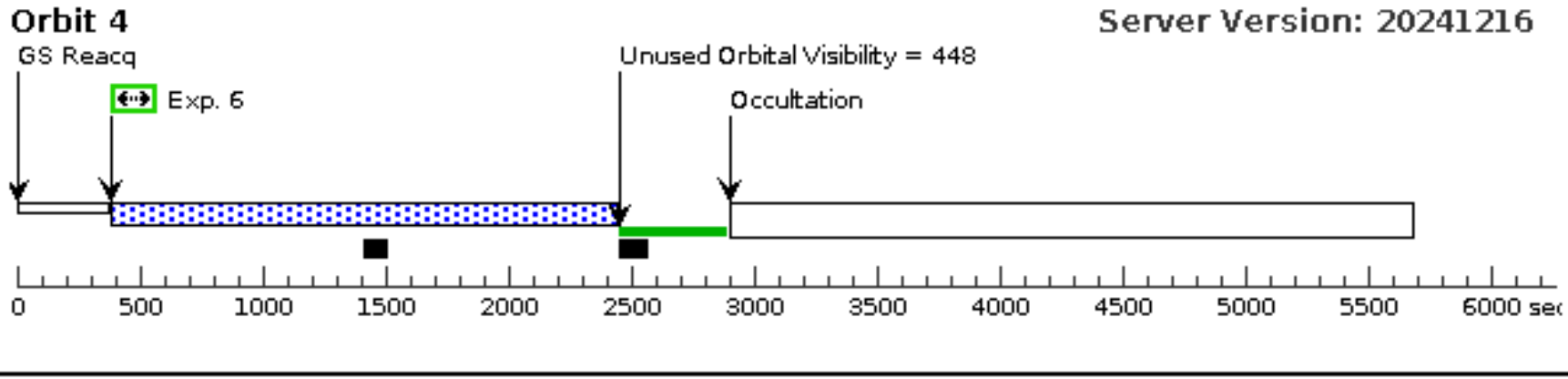
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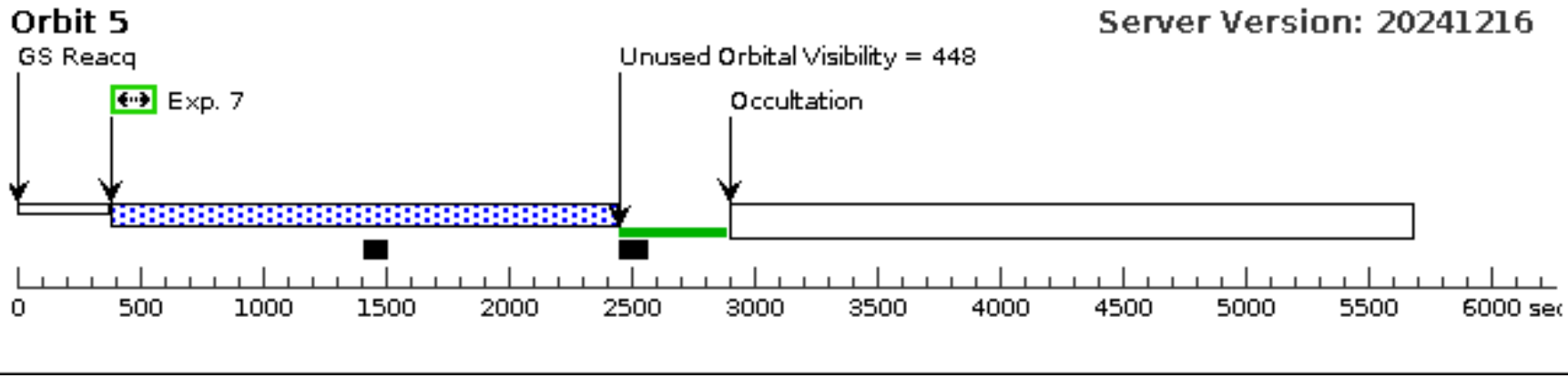
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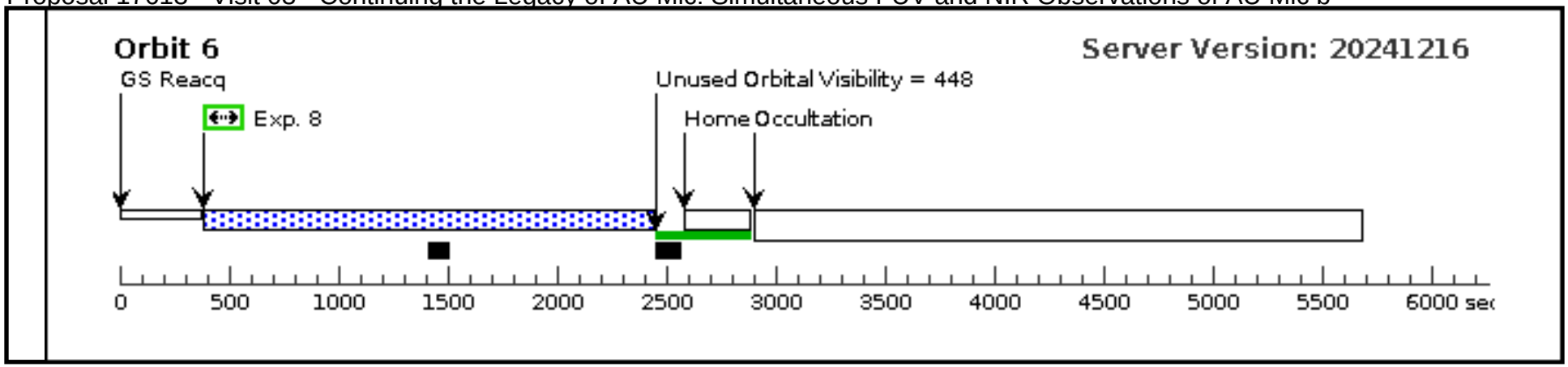
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Visit

Proposal 17613, Visit 04, implementation Mon Apr 21 19:00:16 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: SCHED 100%; Period 8.46314280 D AND ZERO-PHASE HJD2460200.7339

Diagnostics

(Visit 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.

(Visit 04) Warning (Orbit Planner): COS EXPOSURE TIME ROUNDED DOWN TO NEAREST 0.1 SECONDS

(Visit 04) Warning (Orbit Planner): COS EXPOSURE TIME ROUNDED DOWN TO NEAREST 0.1 SECONDS

Fixed Targets

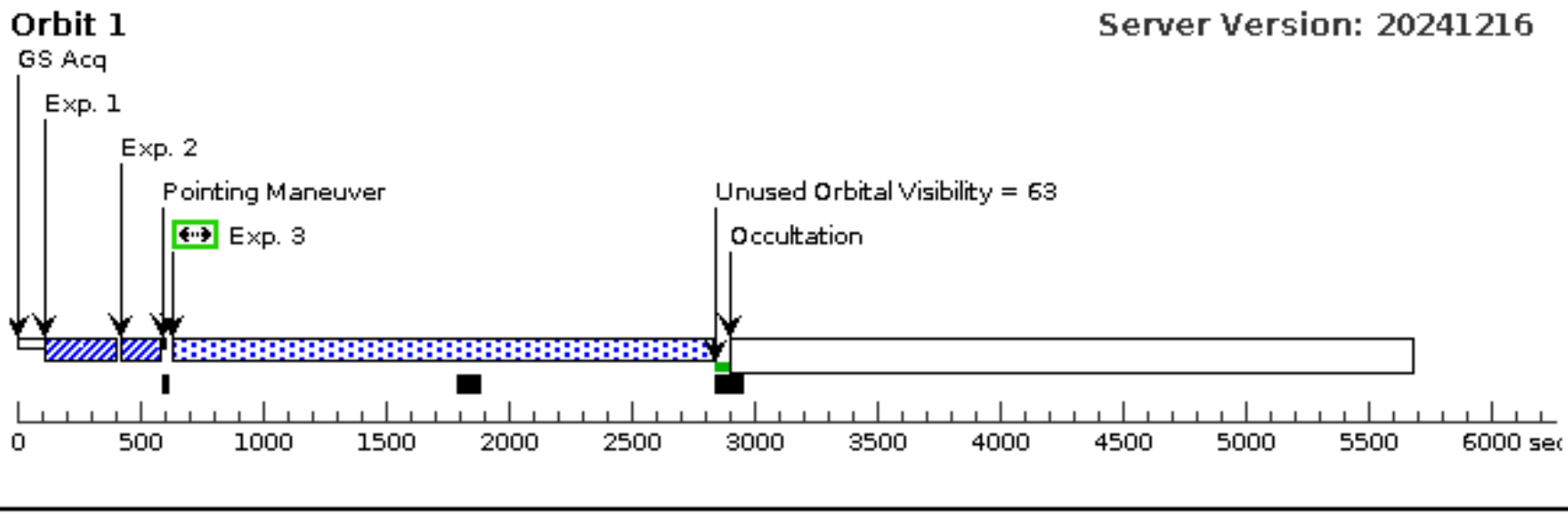
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-AU-MIC	RA: 20 45 9.8729 (311.2911371d) Dec: -31 20 32.82 (-31.34245d) Equinox: J2000	Proper Motion RA: 0.02196719120353366 sec of time/yr Proper Motion Dec: -0.35989499999686814 arcsec/yr Epoch of Position: 2015.5	V=8.627	Reference Frame: ICRS

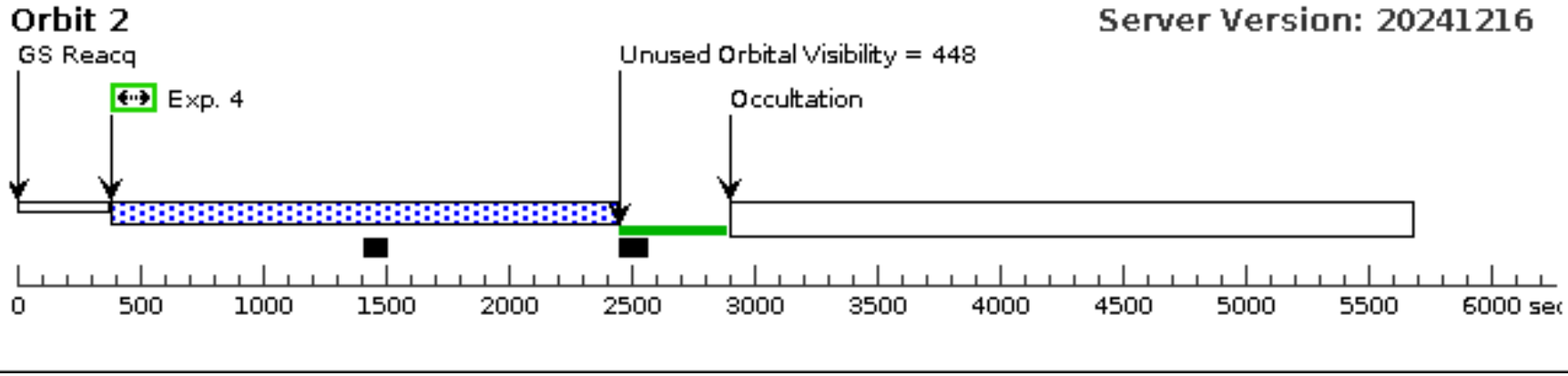
Comments: This object was generated by the target selector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, EXTRA-SOLAR PLANETARY SYSTEM, PRE-MAIN SEQUENCE STAR]
Extended=NO

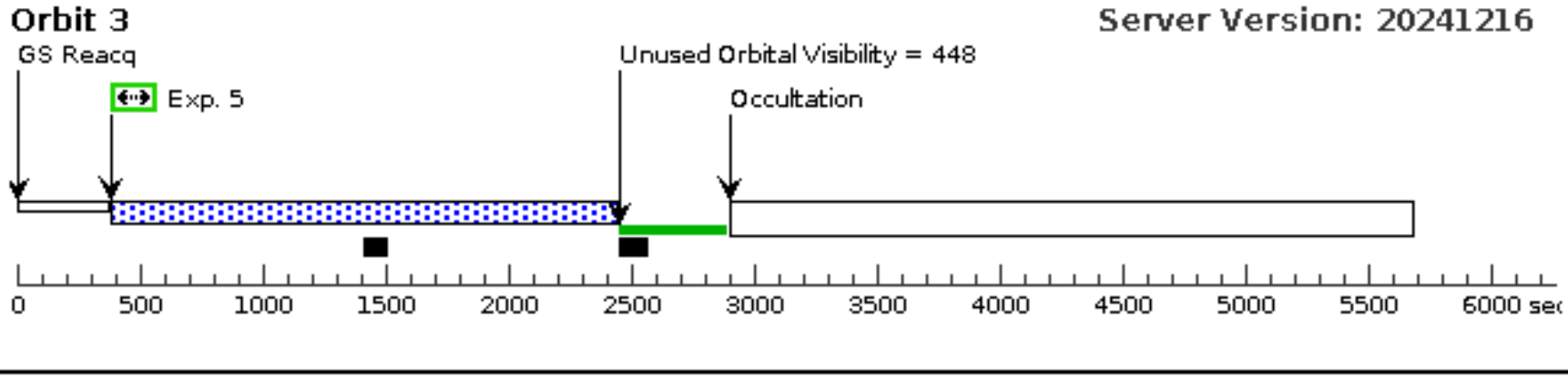
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(1452138)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM	PHASE .96 TO .98		3.3 Secs (3.3 Secs) *[==>]*	*[1]*
2	(1452139)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5; CENTER=FLUX-WT-FLR			2.8 Secs (2.8 Secs) *[==>]*	*[1]*
3	(1448377)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[1]*
4	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	FP-POS=4; BUFFER-TIME=1000			2015 Secs (2015 Secs) *[==>]*	*[2]*
5	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[3]*
6	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[4]*
7	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[5]*
8	(1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=1000; FP-POS=4			2015 Secs (2015 Secs) *[==>]*	*[6]*

Orbit Structure






Orbit 3
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GS Reacq
Exp. 5
Unused Orbital Visibility = 448
Occultation
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1000
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2000
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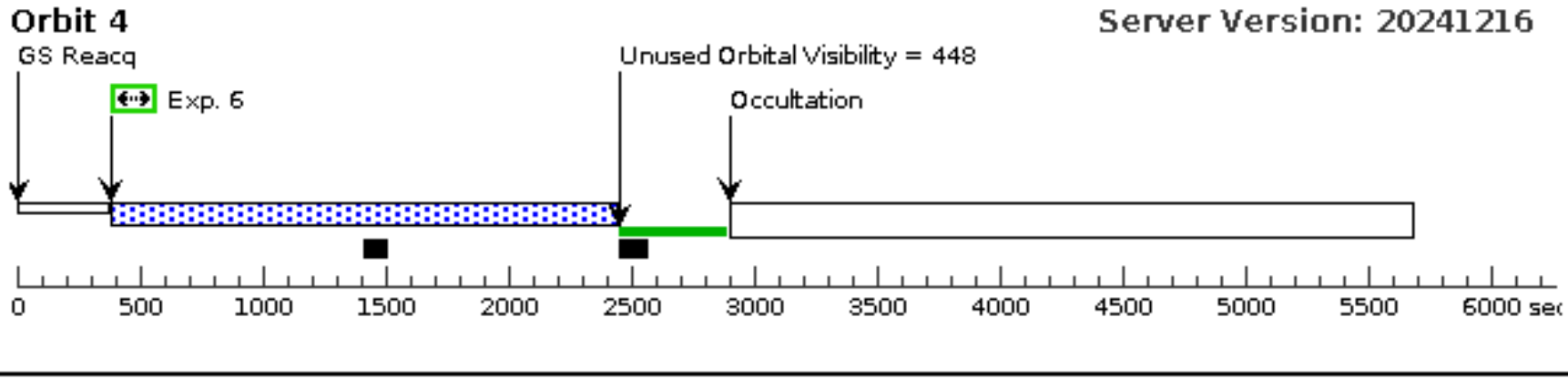
6000 sec


Orbit 4
Server Version: 20241216
GS Reacq
Exp. 6
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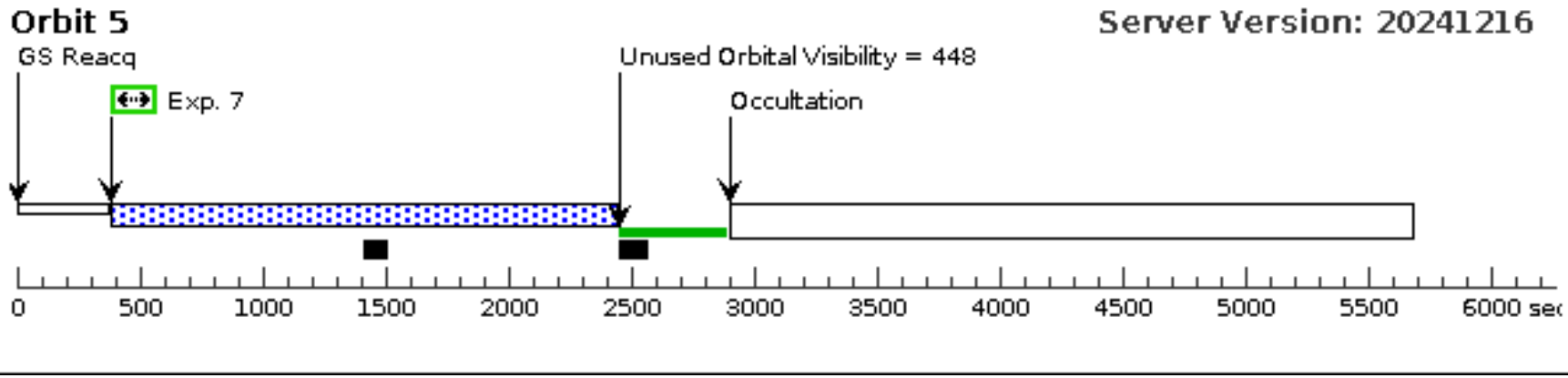
6000 sec


Orbit 5
Server Version: 20241216
GS Reacq
Exp. 7
Unused Orbital Visibility = 448
Occultation
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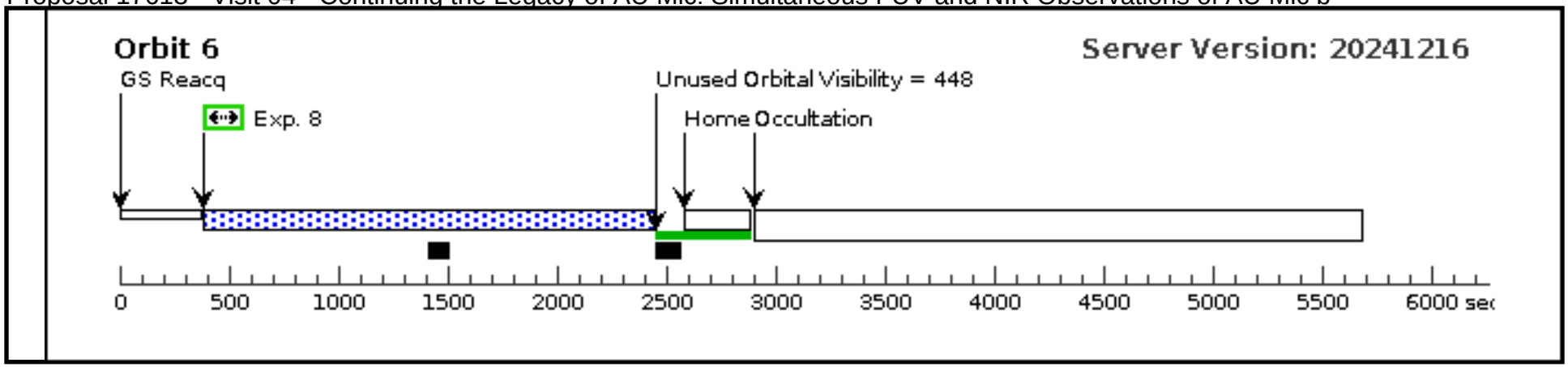
Orbit 6
Server Version: 20241216
GS Reacq
Exp. 8
Unused Orbital Visibility = 448
Home Occultation
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1500
2000
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3000
3500
4000
4500
5000
5500
6000 sec