16164 - Measuring mass loss via metal lines from the very young planet AU Mic b

Cycle: 28, 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) V-AU-MIC	COS/FUV COS/NUV	5	02-Apr-2021 10:00:52.0	yes
02	(1) V-AU-MIC	COS/FUV COS/NUV	5	02-Apr-2021 10:00:53.0	yes
03	(1) V-AU-MIC	COS/FUV COS/NUV	5	02-Apr-2021 10:00:54.0	yes

15 Total Orbits Used

ABSTRACT

The known populations of super-Earths and sub-Neptunes with orbital periods less than ~100 days have been shaped by atmospheric evaporation, leading to the observed Radius Valley near 1.7 Earth radii. However, it is currently unclear what the dominant mass loss mechanism is for these planets. The two likely culprits are photoevaporation by the host star's high energy radiation and core-powered evaporation, where the latent heat of formation in the planet's core causes the atmosphere to expand and escape. Distinguishing between these two mass loss mechanisms will require much more precise exoplanet radii statistics or, alternatively, measurements of mass loss for planets of varying ages and incident high energy flux. We propose to address this critical question by using COS to observe the transit of the ~20 million year old planet AU Mic b and measure its mass loss rate in UV metal lines of carbon, silicon, and oxygen. AU Mic is the brightest pre-main sequence star known to host a transiting planet and offers a unique opportunity to detect the planet's atmosphere at very high signal-to-noise in a number of UV mass loss indicators. Furthermore, information from the UV metal lines is complementary to absorption in the hydrogen Lyman-alpha line, which is heavily attenuated by the ISM. The metal lines trace material from the base of the thermosphere, whereas Lyman-alpha samples the highly extended unbound exosphere. Measurements of young planet evaporation rates are vital benchmarks for atmospheric evolution models and AU Mic b is currently the best known exoplanet to perform such an experiment.

OBSERVING DESCRIPTION

We will observe three transits of AU Mic b in order to measure its extended atmosphere in the metal lines O I 1302.2,1304.9,1306.0, C II 1334.5,1336.7, and Si III 1206.5 angstroms. 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 all of the spectral lines of interest, as well as the C III multiplet near 1175 angstroms which we will use to monitor the star's activity level. The same COS setting will be used for all observations.

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 65 - 85 in the O I lines and 75 - 100 in the C II lines. Based on our simulated transits, this results in 68% uncertainties of 1% for the individual transit flux measurements. AU Mic b 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 blocks of time available in during Cycle 28 in which to schedule our transit observations. Thus there should be no obstacle to scheduling the transits. The ephemeris was determined jointly using TESS and Spitzer data collected in August 2018 and February and September 2019,

respectively. The uncertainty on the period is 0.00004 days and the uncertainty on the transit midpoint is 0.0007 days. Propagating the period and midpoint errors predicts that the timing of any transit scheduled in Cycle 28 should be accurate to 2 minutes, which is well within the acceptable timing uncertainty for our science case.

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 less than once every ~16 days (Loyd et al. 2018). This can be compared to the active flare star AD Leo which experiences a flare with the same energy 5 times per day. Thus AU Mic is highly unlikely to show a strong flare during our observations. Our chosen COS conguration also does not contain any of the strongest FUV emission lines (i.e., Ly-alpha, C IV) that are most likely to cause detector damage. We have checked the emission line fluxes in the G130M/1222 bandpass and they fall within the safe range for active M dwarfs.

Visit

Proposal 16164, Visit 01, implementation Fri Apr 02 14:00:55 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: SCHED 100%; Period 8.46299 D AND ZERO-PHASE HJD2458330.39046

Fixed Targets

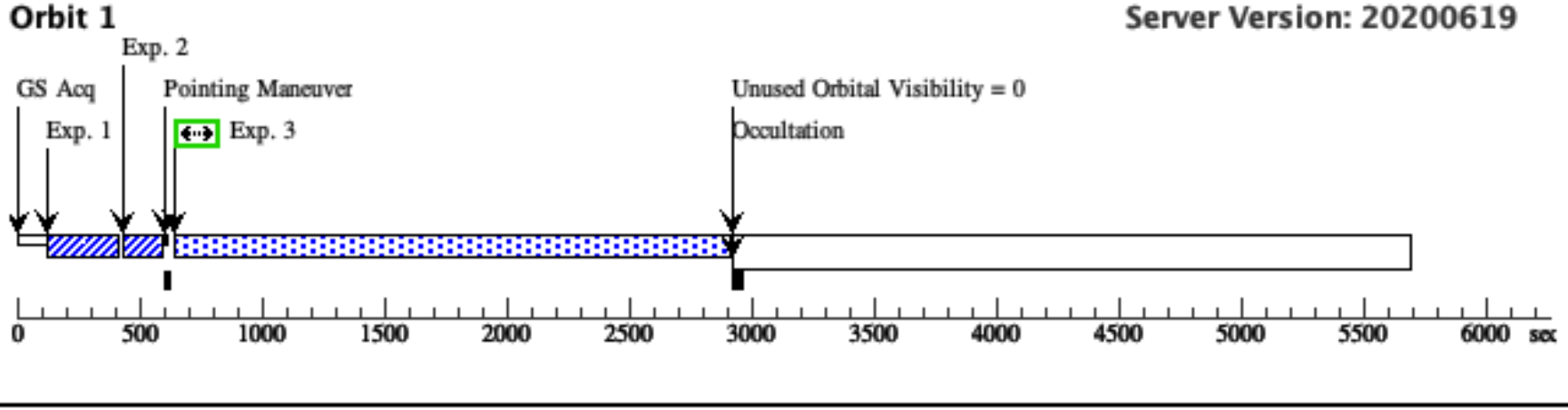
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-AU-MIC	RA: 20 45 9.8729 (311.2911371d) Dec: -31 20 32.82 (-31.34245d) Equinox: J2000	Proper Motion RA: 0.02196719120353366 sec of time/yr Proper Motion Dec: -0.35989499999686814 arcsec/yr Epoch of Position: 2015.5	V=8.627	Reference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

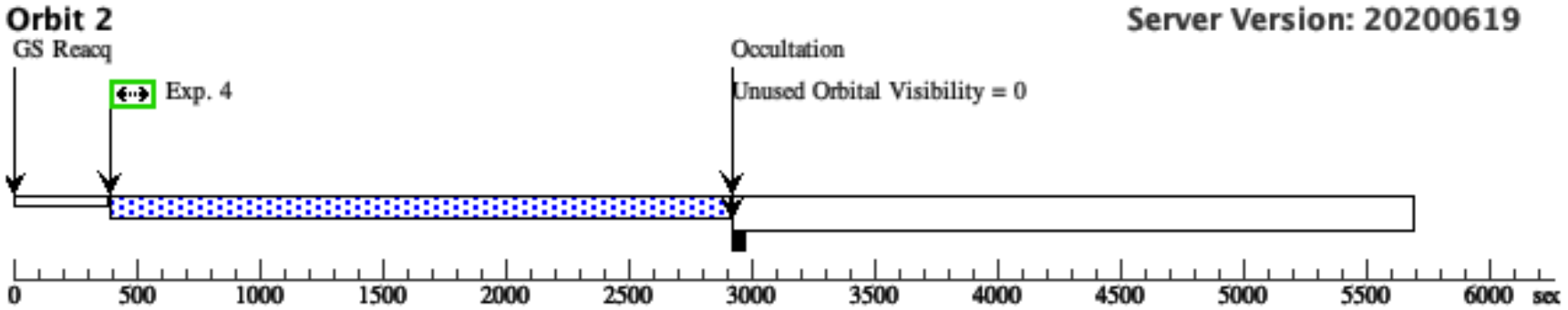
Comments: This object was generated by the target selector and retrieved from the SIMBAD database.
Category=STAR
Description=[M III-I]
Extended=NO

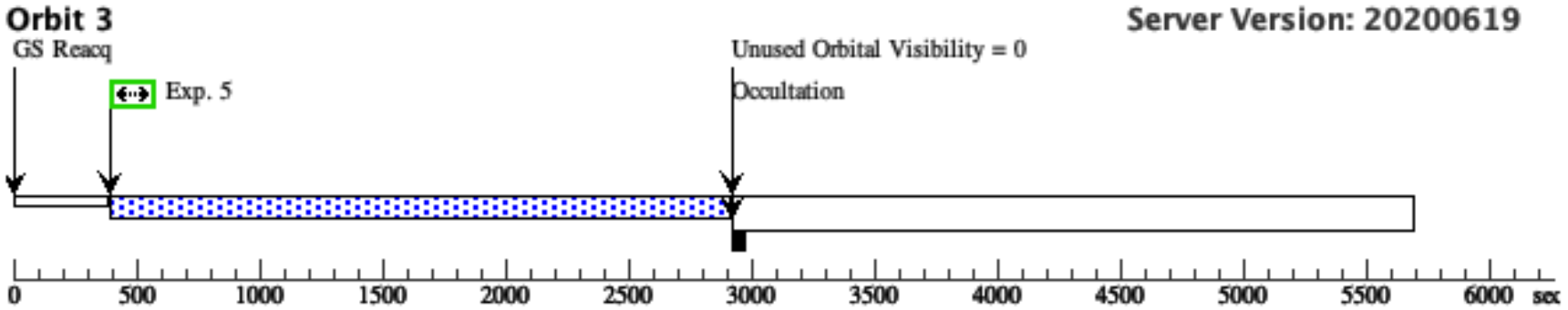
Exposures

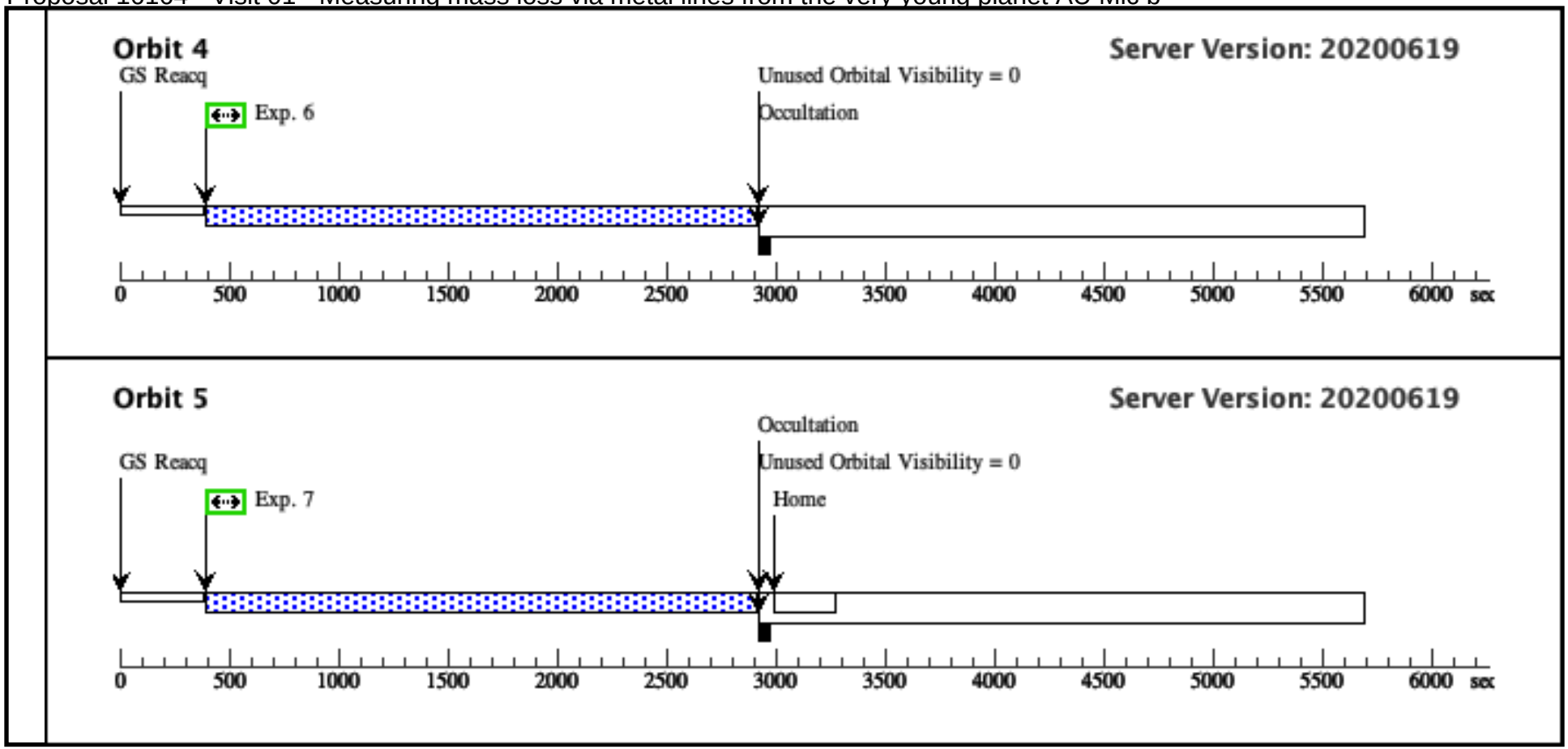
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(1452138)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM	PHASE .972 TO .975; GS ACQ SCENARIO BASE1BE		3.3 Secs (3.3 Secs) *[==>]*	*[1]*
2	(1452139)	(1) 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	(COS.sp.1448377)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2085 Secs (2085 Secs) *[==>]*	*[1]*
4	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	FP-POS=4; BUFFER-TIME=6933			2471 Secs (2471 Secs) *[==>]*	*[2]*
5	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2471 Secs (2471 Secs) *[==>]*	*[3]*
6	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2471 Secs (2471 Secs) *[==>]*	*[4]*
7	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2471 Secs (2471 Secs) *[==>]*	*[5]*

Orbit Structure





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Visit

Proposal 16164, Visit 02, implementation Fri Apr 02 14:00:55 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: SCHED 100%; Period 8.46299 D AND ZERO-PHASE HJD2458330.39046

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Extended=NO

Exposures

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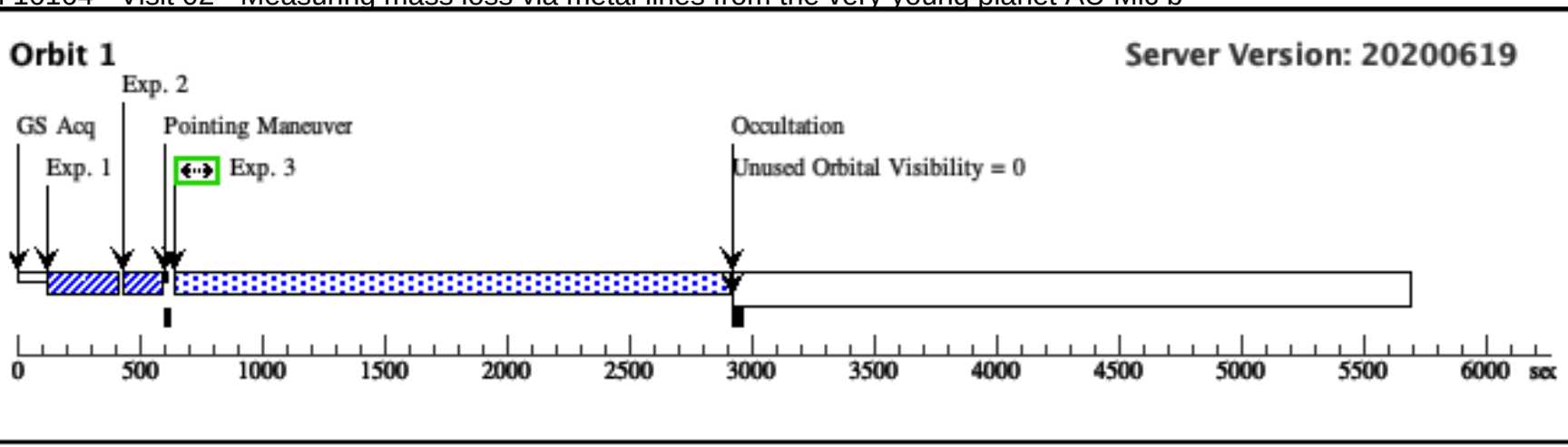
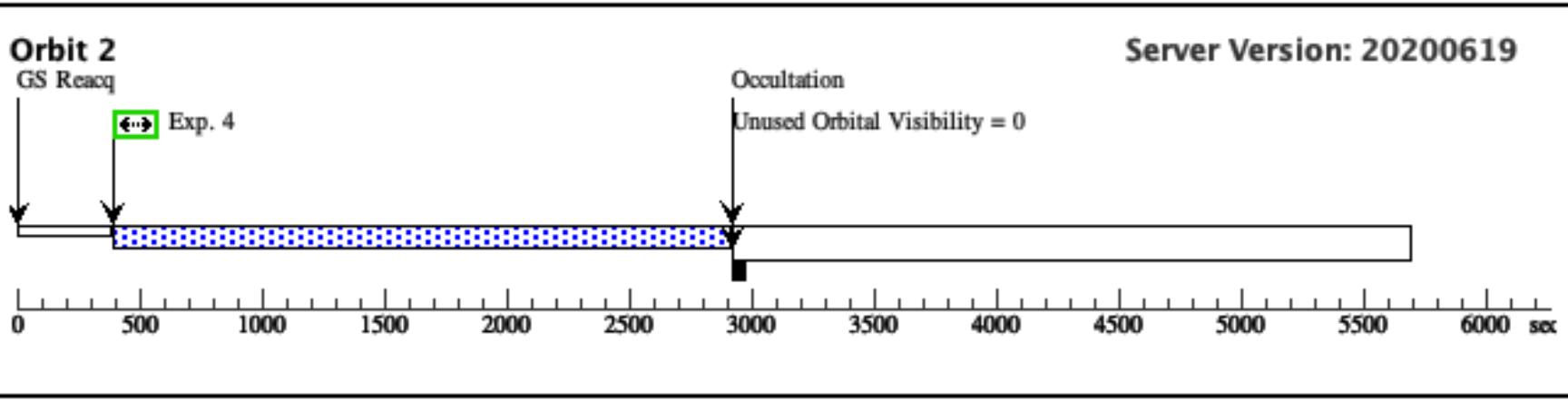
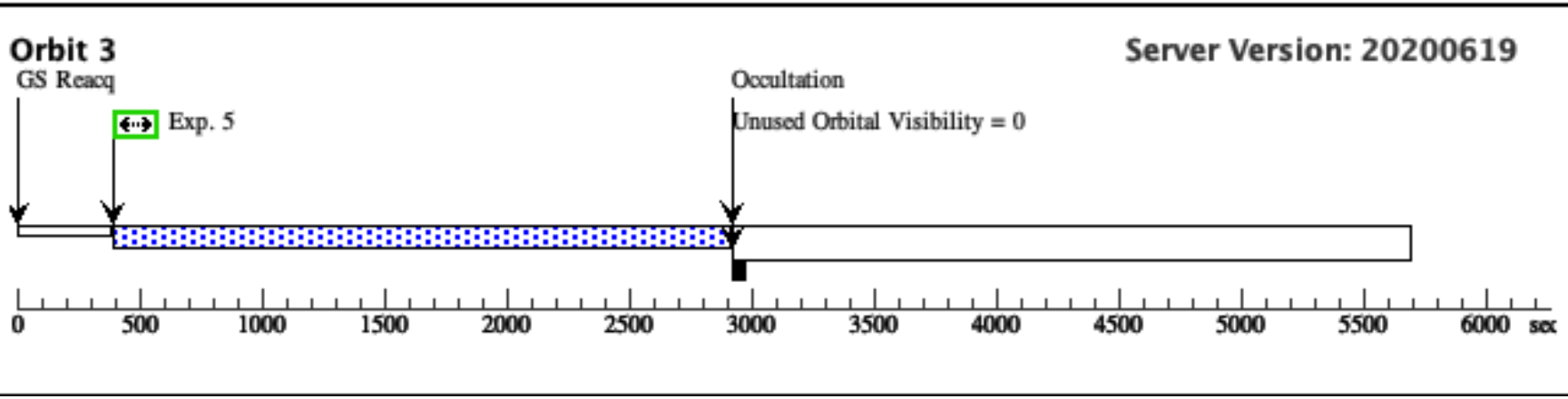
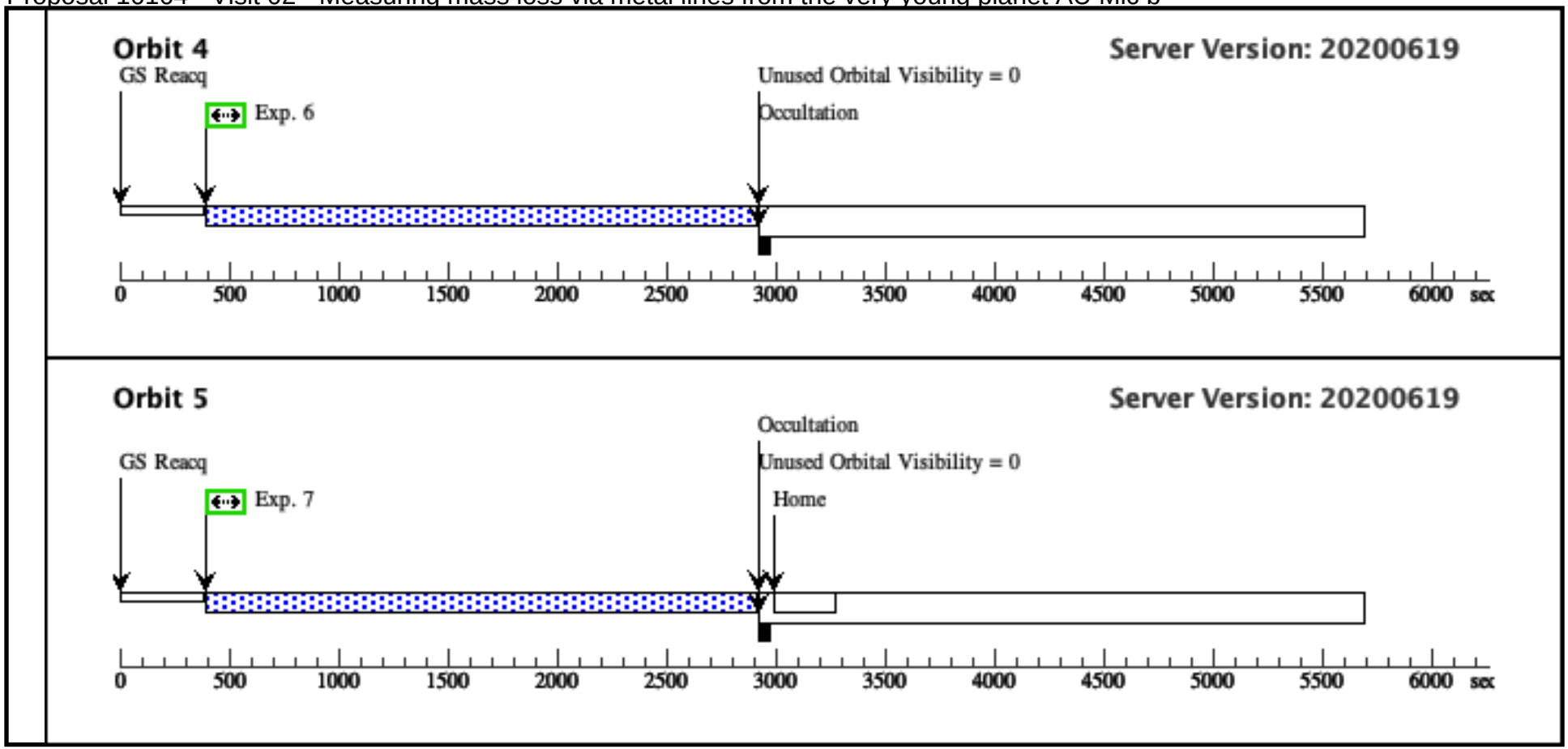
1	(1452138)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM	PHASE .98 TO .982; GS ACQ SCENARIO BASE1BE		3.3 Secs (3.3 Secs) *[==>]*	***[1]***
2	(1452139)	(1) V-AU-MIC	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5; CENTER=FLUX-WT-FLR			2.8 Secs (2.8 Secs) *[==>]*	***[1]***
3	(COS.sp.1448377)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2085 Secs (2085 Secs) *[==>]*	***[1]***
4	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	FP-POS=4; BUFFER-TIME=6933			2471 Secs (2471 Secs) *[==>]*	***[2]***
5	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2471 Secs (2471 Secs) *[==>]*	***[3]***
6	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2471 Secs (2471 Secs) *[==>]*	***[4]***
7	(COS.sp.1448378)	(1) V-AU-MIC	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=6933; FP-POS=4			2471 Secs (2471 Secs) *[==>]*	***[5]***

Orbit Structure





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Visit

Proposal 16164, Visit 03, implementation Fri Apr 02 14:00:55 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

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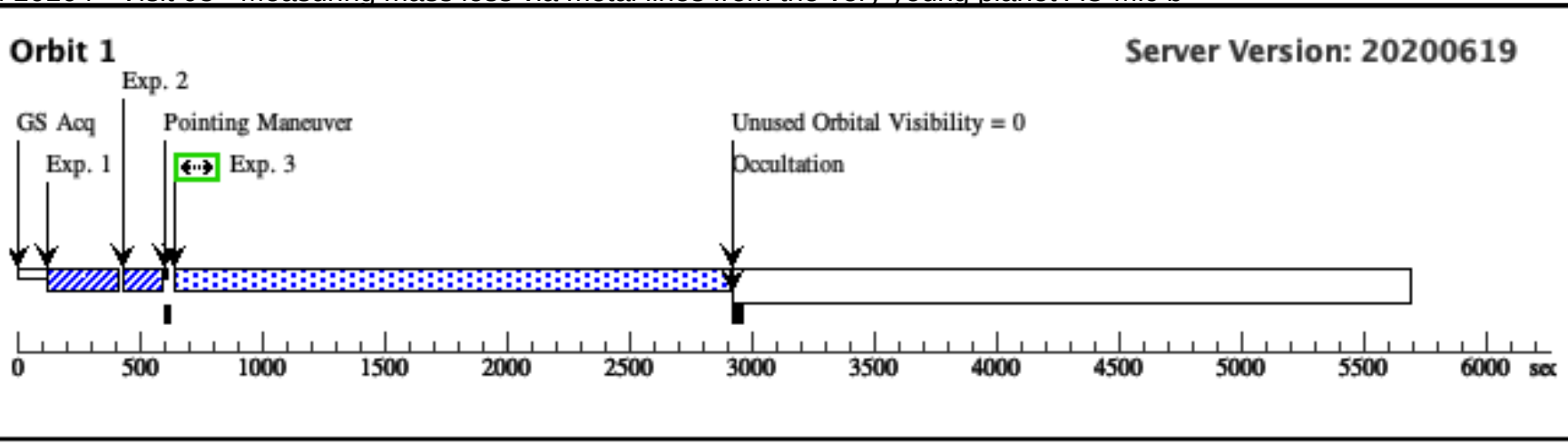
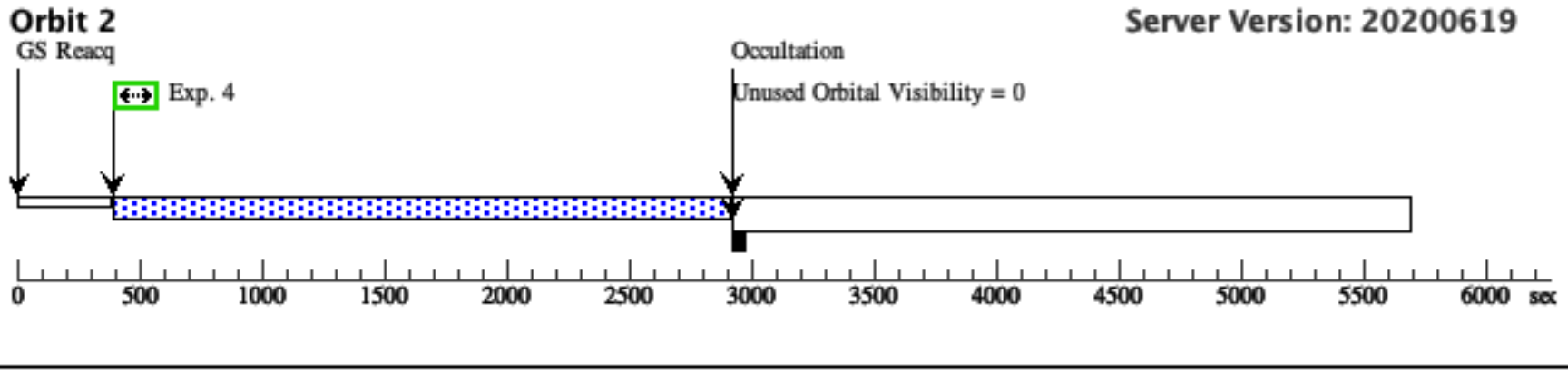
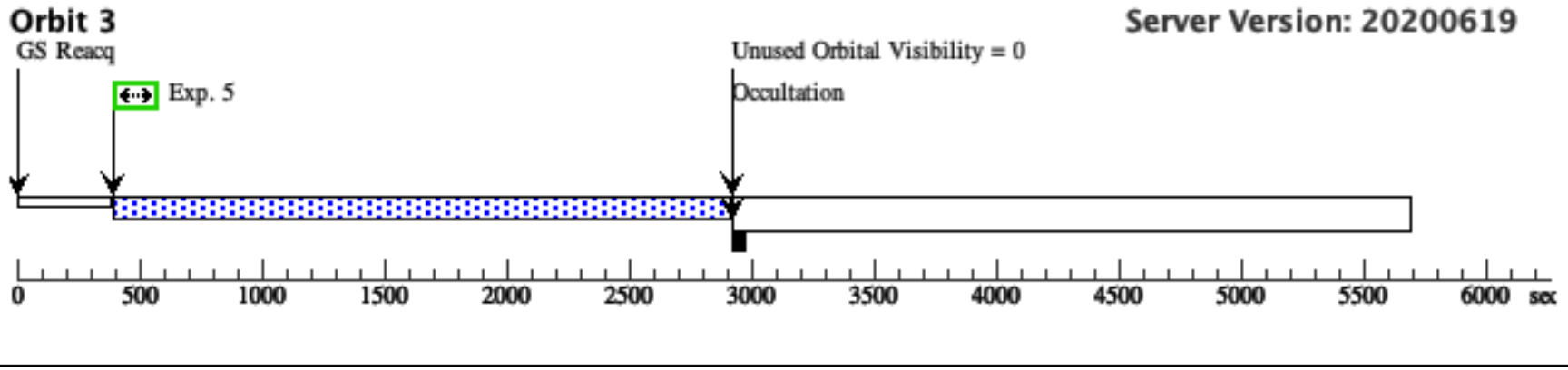
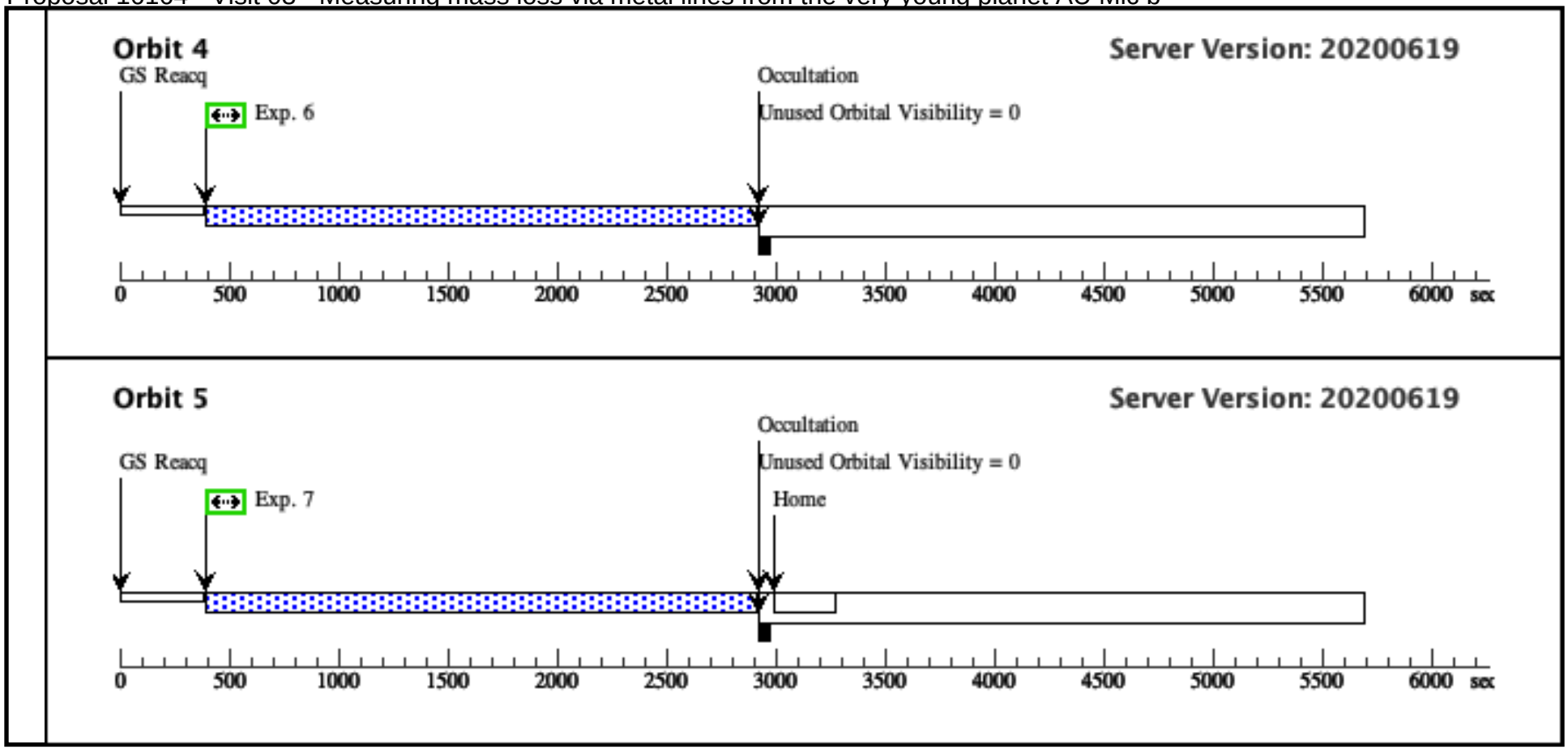
Orbit Structure





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