17762 - Contribution of Non-thermal H to the Martian Water Loss at Solar Maximum

Cycle: 32, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Dr. Dolon Bhattacharyya (PI) (Contact)	**University of Colorado at Boulder**
Prof. John T. Clarke (CoI)	Boston University
Valery Shematovich (CoI)	Institute of Astronomy of the RAS
Prof. Dmitry Bisikalo (CoI)	Institute of Astronomy of the RAS

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) MARS-EXOSPHERE (2) SKY-NEAR-MARS (3) MARS-EXOSPHERE-EXTENDED	ACS/SBC	3	18-Mar-2025 15:00:32.0	yes
02	(1) MARS-EXOSPHERE (2) SKY-NEAR-MARS (3) MARS-EXOSPHERE-EXTENDED	ACS/SBC	3	18-Mar-2025 15:00:34.0	yes

6 Total Orbits Used

ABSTRACT

Determining the total amount of water lost by Mars over its ~4.3 billion year history has been the subject of contention in the Mars community for the past few decades. Recent advances led to the discovery of a magnitude change in water escape rate during the perihelion season every Mars year. This has increased the initial estimates of the total amount of water lost by Mars from 3.6m of Global Equivalent Layer (GEL) to 23m, an increase by a factor of 5. Another recent discovery with HST has been detecting the observational signature of non-thermal/hot H in the exosphere of Mars. The escape rate of such atoms was found to be ~26% of the thermal escape rate at solar minimum, further elevating the water loss estimates from Mars. Data analysis revealed that solar wind is the major driver in the creation of this population. At present the effect of solar activity on the creation of hot H at Mars and the consequence on water escape rate is unknown. Hence the proposal is to determine the correlation between non-thermal H escape rate and solar activity at Mars. Characterizing this population is critical as hot H atoms are present in the exospheres of all solar system planets and likely exoplanets as well. Because the younger Sun was more active, and there are many exoplanetary systems with active star hosts, escape of hot H could have important implications on the habitability and water escape history of planets. This proposal supports the HST UV initiative.

OBSERVING DESCRIPTION

We propose to obtain ACS SBC UV images of Mars to study the characteristics of the non-thermal hydrogen atoms populating the exosphere of Mars. Hydrogen atoms resonantly scatter solar Lyman alpha photons (far-ultraviolet wavelengths) that can be imaged using the ACS detector and a combination if filters onboard the HST. More specifically, each observing run would be a series of clear and filtered images, with the F140LP filter used to image Mars with the Lyman alpha photons blocked and the F115LP (clear) filter which allows the Lyman alpha emission from Mars through to the detector. The scaled difference between the clear and filtered images reveals the Lyman alpha coming from the hydrogen atoms present in the exosphere of Mars. This is very effective in studying the Martian exosphere, as above ~250 km from the Martian surface most of the emission is Lyman alpha.

Sky observations near Mars are critically important to accurately subtract the Lyman alpha emissions coming from the background geocorona and interplanetary hydrogen. The allotted orbits would be divided into a series of 3 visits of 2 orbits each, one observing Mars and one for the sky background 5 arcminute away from Mars for a total of 5 orbits. The three visits would be spaced over a time period of 2.5 months which would allow us to monitor changes in the hot hydrogen population at Mars as Mars approaches aphelion and crosses it at solar maximum.

HST is the only facility that has the UV sensitivity, necessary angular resolution as well as much larger altitude coverage in order to image the extended hot hydrogen exosphere of Mars. While MAVEN and MEX are capable of measuring the lower exosphere with higher altitude resolution that is fruitful towards studying latitudinal differences, they are not capable of imaging the more energetic hydrogen atoms that reside at the highest reaches of the Martian exosphere. This study will greatly aid in providing a better estimate of the timeline for the water loss history from Mars.

The ACS/SBC clear (F115LP) images will be taken during the shadow portion of HST's orbit, and the filtered (F140LP) images will be taken when HST is in sunlight to minimize the brightness contributed by the geocoronal H atoms at Lyman alpha. One HST orbit during each observing run will be dedicated towards measuring the background emissions from the interplanetary hydrogen and the geocorona. It is imperative that the background emissions be measured relative to HST's orbital location as experience with past programs has shown that the geocorona is too variable to be modeled with high accuracy for deriving the Lyman alpha emissions from the Martian exosphere. This is very important towards determining the faint emissions from the Martian hydrogen exosphere far from Mars.

The count rates for ACS SBC clear (F115LP) imaging of Mars range from 5000-80000 counts/sec as determined from earlier HST observing campaigns. This count rate is well below the limit of 200,000 counts/sec, and the local count rate limits are also not exceeded. Count rates with F140LP filter are much lower since this filter blocks Lyman alpha emission. The roll angle will be unconstrained for this program. Since Mars moves accross the sky, this generally makes it possible to locate good guide stars within any week-long observing window, and it has been shown in GO 11170, 13794, and 14752 that bright object protection and counting rate limits will not hinder the observations, even when Mars is close to the Sun.

Proposal 17762 - Visit 01 - Contribution of Non-thermal H to the Martian Water Loss at Solar Maximum

Visit

Proposal 17762, Visit 01, completed Tue Mar 18 19:00:35 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: ACS/SBC

Special Requirements: BETWEEN 26-NOV-2024:00:00:00 AND 10-DEC-2024:00:00:00

Diagnostics

(Exposure 1 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 2 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 4 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 5 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 6 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Visit 01) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Solar System Targets

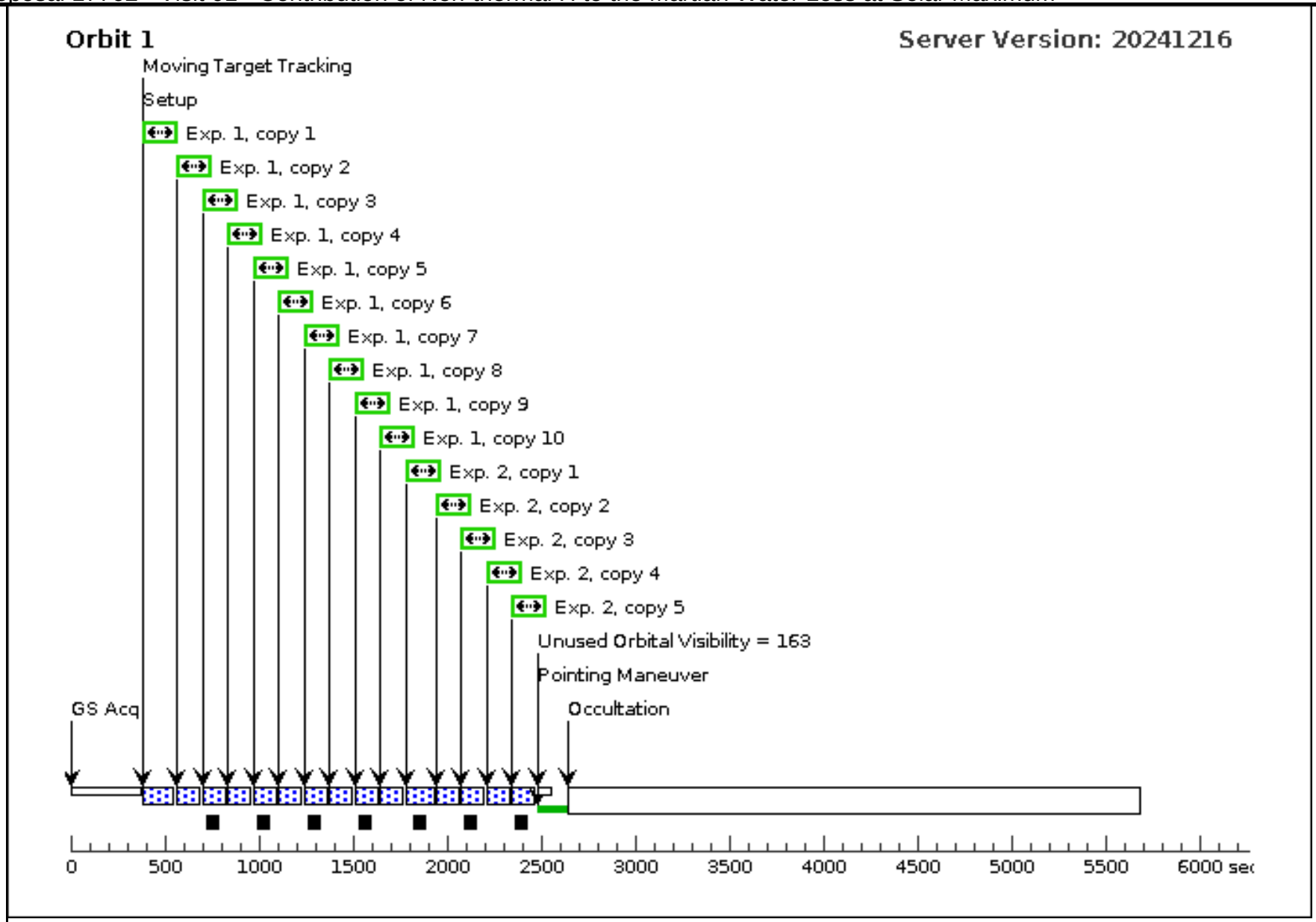
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	MARS-EXOSPHERE	STD=MARS	TYPE=POS_ANGLE,RAD=12,ANG=172,REF=NORTH		NOT OCC OF MARS-EXOSPHERE BY MARS FROM EARTH	EARTH
Comments: Description=Mars exospheric Ly-a emission						
(2)	SKY-NEAR-MARS	STD=MARS	TYPE=POS_ANGLE,RAD=300,ANG=0,REF=NORTH		NOT OCC OF SKY-NEAR-MARS BY MARS FROM EARTH	EARTH
Comments: Description=Sky background near Mars						
(3)	MARS-EXOSPHERE-EXTENDED	STD=MARS	TYPE=POS_ANGLE,RAD=35,ANG=172,REF=NORTH		NOT OCC OF MARS-EXOSPHERE-EXTENDED BY MARS FROM EARTH	EARTH
Comments: Description=Extended exosphere of Mars with non-thermal H dominating portions						

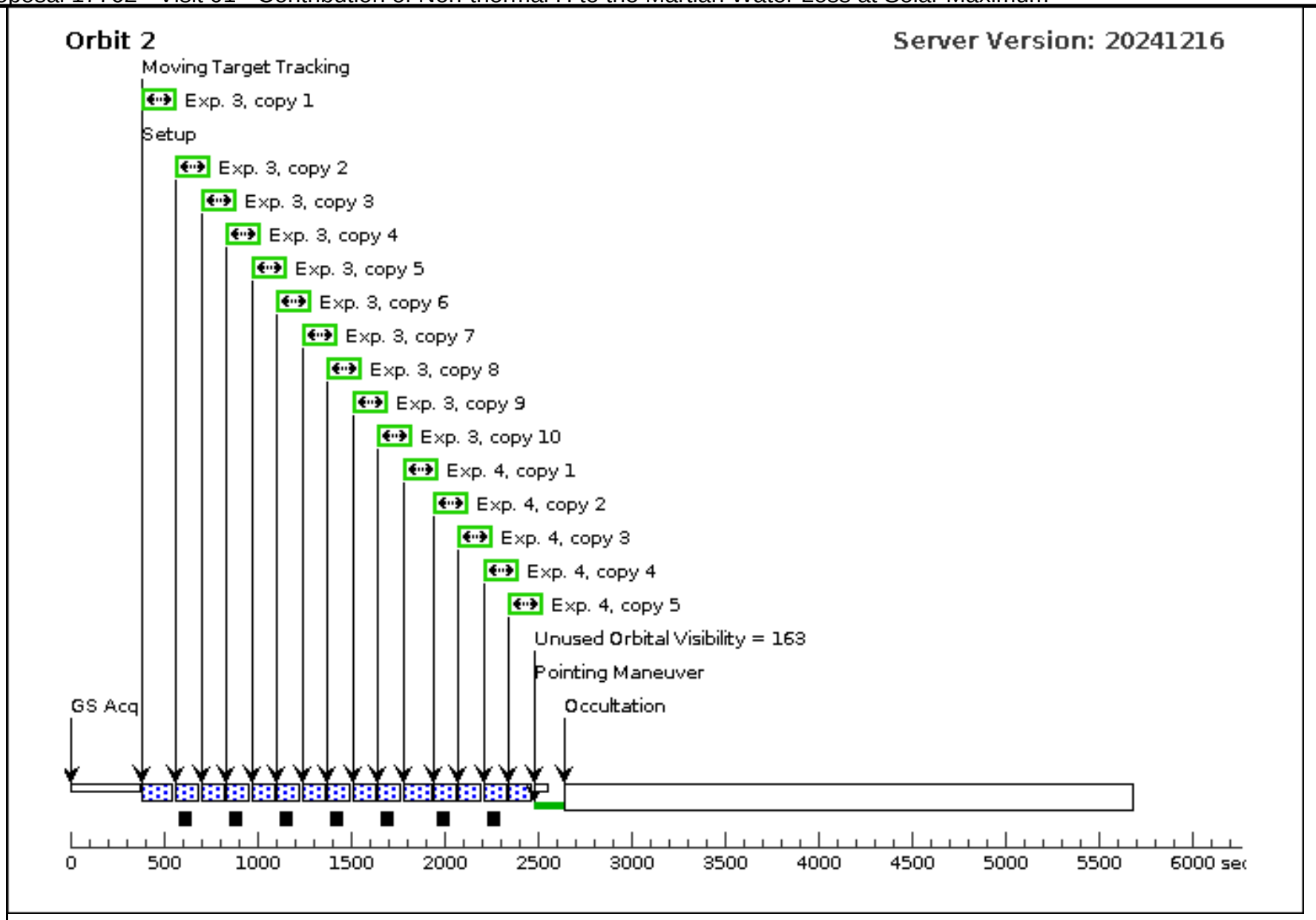
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) MARS-EXOSPHERE	ACS/SBC, ACCUM, SBC	F115LP				95 Secs X 10 (950 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[1]***
2		(1) MARS-EXOSPHERE	ACS/SBC, ACCUM, SBC	F140LP				95 Secs X 5 (475 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[1]***
3		(3) MARS-EXOSPHERE-EXTENDED	ACS/SBC, ACCUM, SBC	F115LP		NEW OBSET FULL ACQ		95 Secs X 10 (950 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[2]***
4		(3) MARS-EXOSPHERE-EXTENDED	ACS/SBC, ACCUM, SBC	F140LP				95 Secs X 5 (475 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[2]***

	5	(2) SKY-NEAR-MARS	ACS/SBC, ACCUM, SBC	F115LP	NEW OBSET FULL ACQ	95 Secs X 10 (950 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[3]***
	6	(2) SKY-NEAR-MARS	ACS/SBC, ACCUM, SBC	F140LP		95 Secs X 5 (475 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[3]***

Orbit Structure

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Exp. 4, copy 2
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Exp. 4, copy 4
Exp. 4, copy 5
Unused Orbital Visibility = 163
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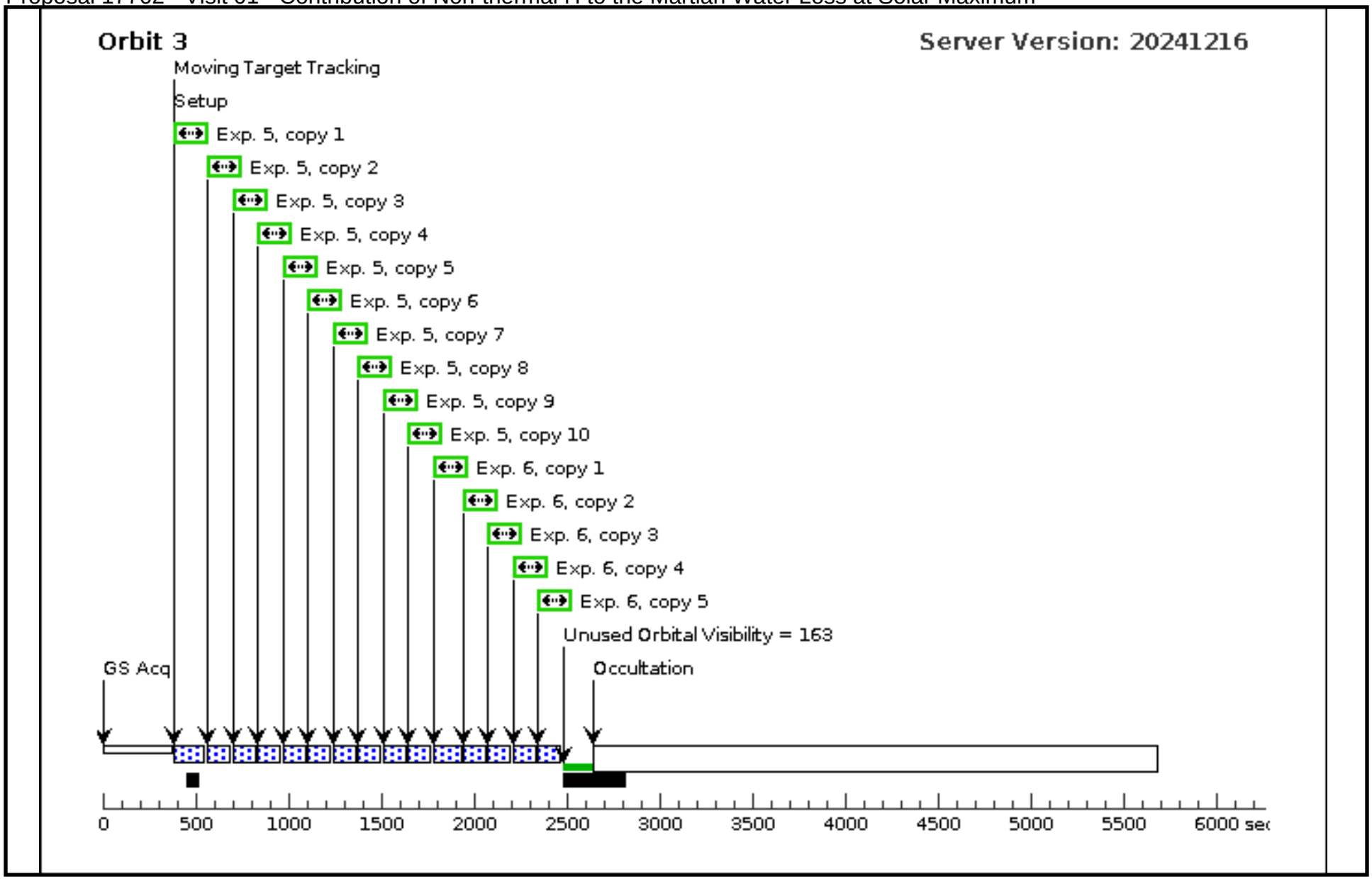
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Server Version: 20241216
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Exp. 6, copy 4
Exp. 6, copy 5
Unused Orbital Visibility = 163
GS Acq
Occultation
0
500
1000
1500
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3500
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4500
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5500
6000 sec

Visit

Proposal 17762, Visit 02, implementation Tue Mar 18 19:00:35 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: ACS/SBC

Special Requirements: BETWEEN 30-SEP-2026:00:00:00 AND 20-JAN-2027:00:00:00

Diagnostics

(Exposure 1 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 2 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 4 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

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3		(3) MARS-EXOSPHERE-EXTENDED	ACS/SBC, ACCUM, SBC	F115LP		NEW OBSET FULL ACQ		95 Secs X 10 (950 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[2]***
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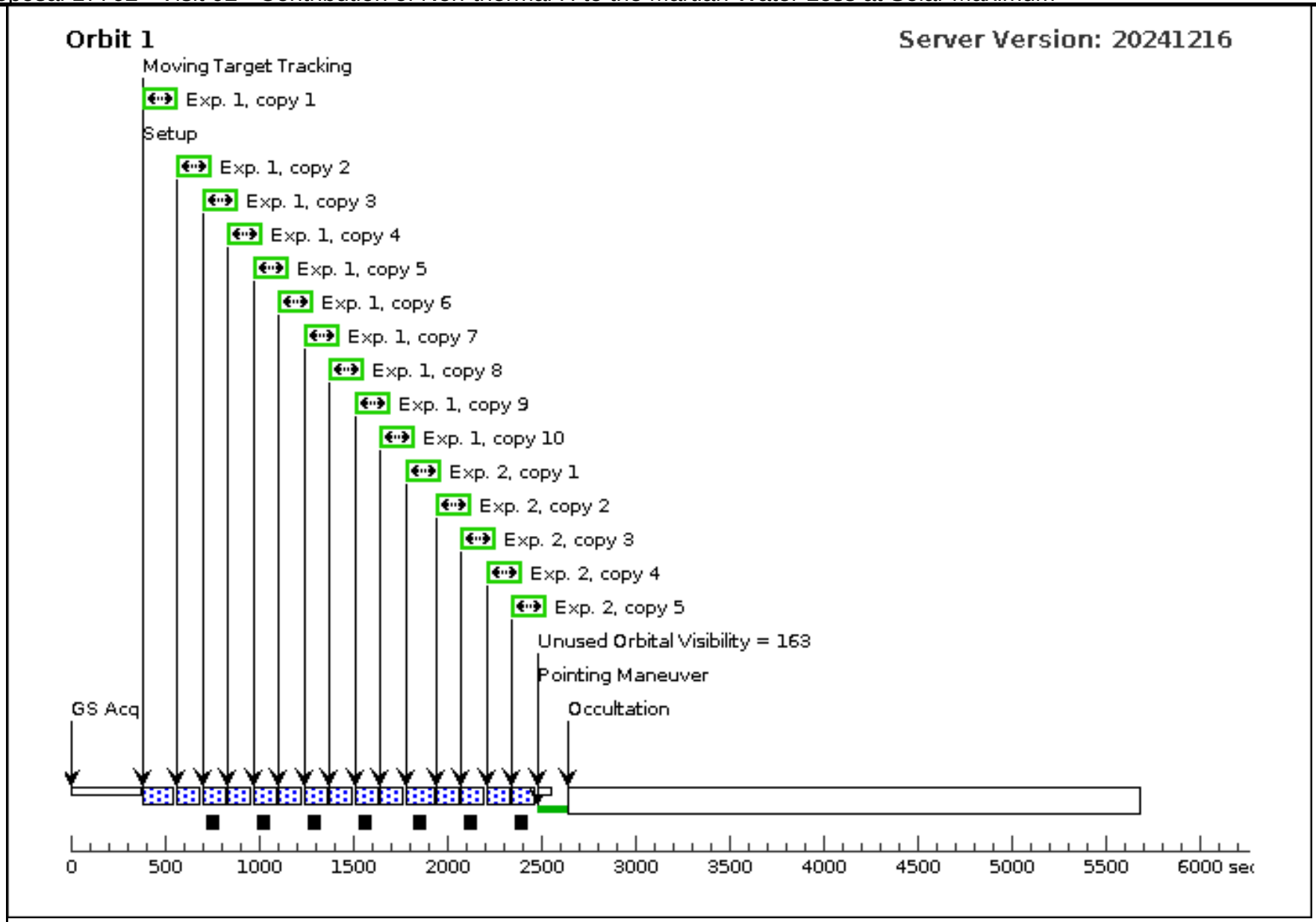
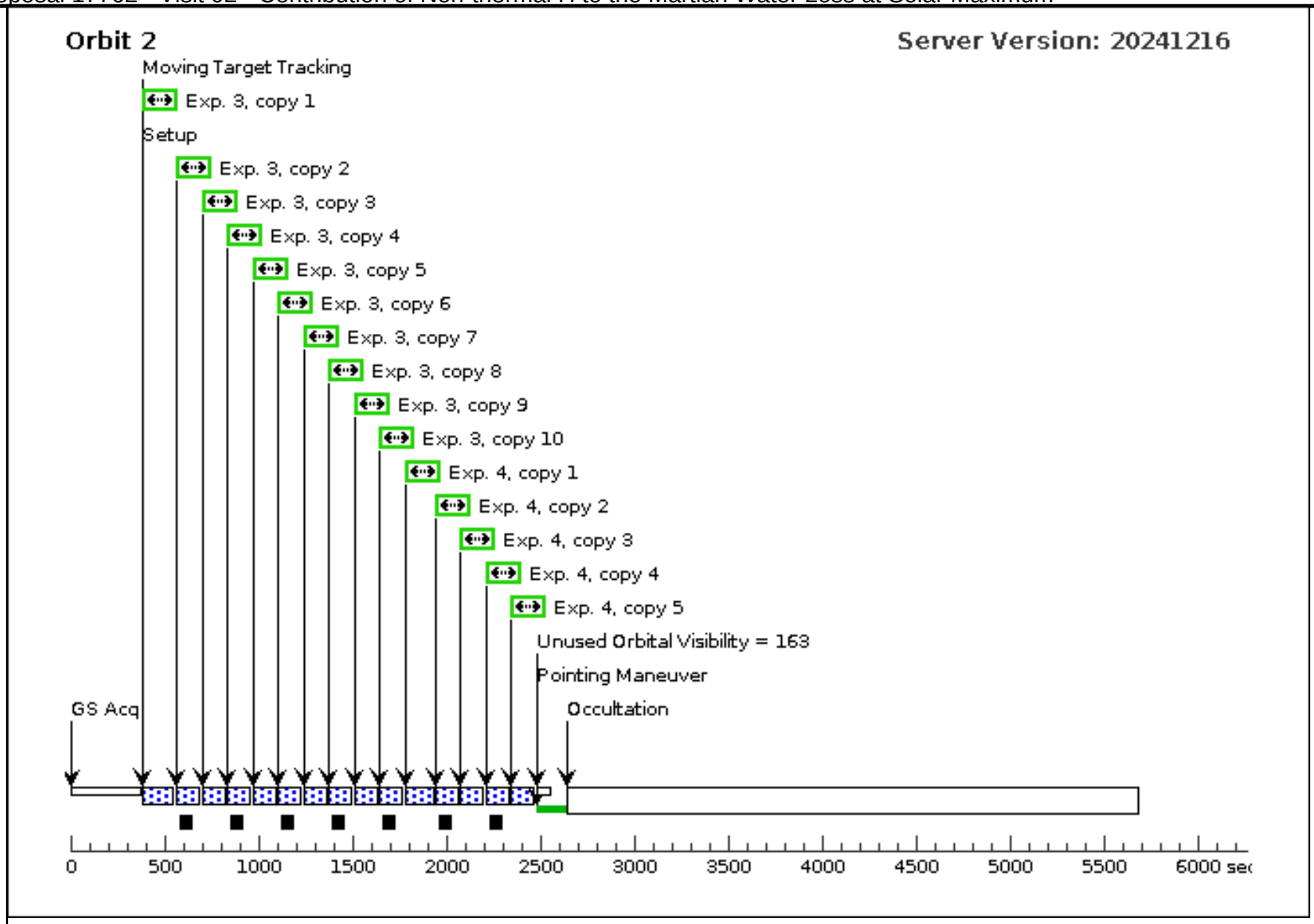
	5	(2) SKY-NEAR-MARS	ACS/SBC, ACCUM, SBC	F115LP	NEW OBSET FULL ACQ	95 Secs X 10 (950 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[3]***
	6	(2) SKY-NEAR-MARS	ACS/SBC, ACCUM, SBC	F140LP		95 Secs X 5 (475 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[3]***

Orbit Structure

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Moving Target Tracking
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Exp. 3, copy 2
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Exp. 3, copy 10
Exp. 4, copy 1
Exp. 4, copy 2
Exp. 4, copy 3
Exp. 4, copy 4
Exp. 4, copy 5
Unused Orbital Visibility = 163
Pointing Maneuver
GS Acq
Occultation
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500
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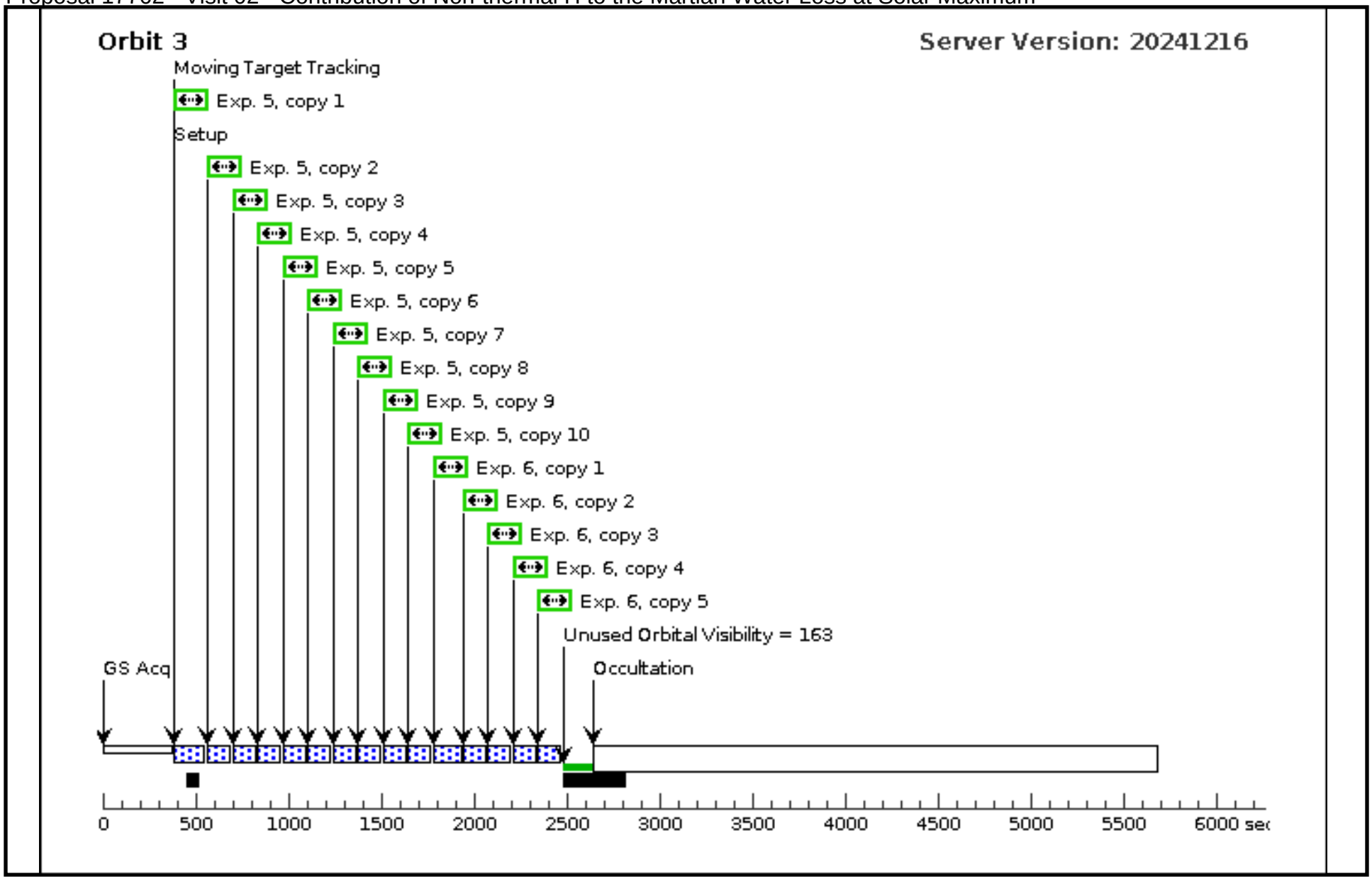
6000 sec


Orbit 3
Server Version: 20241216
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Exp. 5, copy 1
Setup
Exp. 5, copy 2
Exp. 5, copy 3
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Exp. 5, copy 5
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Exp. 5, copy 7
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Exp. 6, copy 2
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Exp. 6, copy 5
Unused Orbital Visibility = 163
GS Acq
Occultation
0
500
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