



14931 - Energy balance in Saturn's upper atmosphere: Joint Lyman-alpha airglow observations with HST and Cassini

Cycle: 24, Proposal Category: GO/DD

(Availability Mode: AVAILABLE)

INVESTIGATORS

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VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) SATURN-DISK (4) TITAN	STIS/CCD STIS/FUV-MAMA	4	14-Aug-2017 17:06:59.0	yes
1A	(3) SATURN-SKY-OFFSET	STIS/FUV-MAMA	1	14-Aug-2017 17:07:00.0	yes
02	(1) SATURN-DISK (2) SATURN-LIMB (4) TITAN	STIS/CCD STIS/FUV-MAMA	4	14-Aug-2017 17:07:03.0	yes
2A	(3) SATURN-SKY-OFFSET	STIS/FUV-MAMA	1	14-Aug-2017 17:07:04.0	yes

10 Total Orbits Used

ABSTRACT

This proposal is for HST UV spectroscopy of Saturn's disk-reflected Lyman-alpha line (Ly-a) at the same time as Cassini airglow measurements. Saturn's Ly-a emission is composed of solar and interplanetary (IPH) Ly-a photons scattered by its upper atmosphere. The H I Ly-a line probes different upper atmospheric layers down to the homopause, providing an independent way to investigate the H I abundance and energy balance. However, this is a degenerate, multi-parameter, radiative-transfer problem that depends on: H I column density, scattering process by thermal and superthermal hydrogen, time-variable solar and IPH sources, and instrument calibration. Our joint HST-Cassini campaign should break the degeneracy in the Saturn airglow problem. First, line-integrated fluxes simultaneously measured by HST/STIS (dayside) and Cassini/UVIS (nightside), avoiding solar variability, should resolve the solar and IPH sources. Second, high-resolution spectroscopy with STIS will reveal superthermal line broadening not accessible with a low-resolution spectrometer like UVIS. Third, a second visit observing the same limb of Saturn will cross-calibrate the instruments and, with the STIS linewidth information, will yield the H I abundance, a key photochemical parameter not measured by Cassini. Finally, the STIS latitudinal mapping of the Ly-a linewidth will be correlated with Cassini's latitudinal temperature profile of the thermosphere, to provide an independent constraint on the thermospheric energy budget, a fundamental outstanding problem for giant planets. Implementing the proposed UV campaign before the end of the Cassini mission is a unique opportunity that may not return for decades.

OBSERVING DESCRIPTION

We will perform two joint HST and Cassini, cross-calibration observations of the Saturn Lyman-alpha (1216 Å, Ly-a) emission:

Visit 1 (5 HST orbits with STIS), DOY 238 2017, corresponding to August 26, when Cassini will observe at 10:34 - 18:34 UT, and

Visit 2 (5 HST orbits with STIS), DOY 245 2017, corresponding to September 02, when Cassini will observe at 01:59 - 08:46 UT.

The HST/STIS visits should be scheduled as close as possible (simultaneous or within a day or less) to the Cassini observations.

This time-critical requirement will keep the solar Ly-a flux parameter nearly unchanged between the HST and Cassini observations (within ~10%), making the brightness comparison useful. The selected dates for the coordinated observations were also chosen because the IPH and geocoronal Ly-a lines will be at their weakest (solar minimum activity) and furthermore Doppler-shifted to the blue, leaving the red-wing of Saturn's Ly-a free of sky background contamination. No other Cassini sequences can fulfill our joint science goals before Cassini plunges into Saturn on Sep 15. The simultaneous HST/Cassini observation will greatly enhance the science return. We greatly appreciate the effort from the staff at STScI in helping achieve this scheduling.

In Visit 1, Aug 26, we will point near the center of the disk of the planet.

In Visit 2, Sep 02, we will target the north bright limb of Saturn. The long spectroscopic slit(s) will be placed inside the disk and crossing the limb, to measure the brightness variation across the limb with a disk reference. (We will no longer place the long slit(s) almost parallel to the limb.)

Both pointings will avoid Saturn's high-latitude auroral regions poleward of +65 degrees latitude to prevent cross-order contamination from the auroral H2 FUV emissions (Clarke et al. 2005).

Each visit will consist of:

-- Orbit 1: ACQ on one of Saturn's moons (e.g., Titan, NUV) for accurate pointing.

-- Orbits 1,2,3: High-resolution STIS/E140H Echelle exposures with the long 52x0.5" slit (time-tagged) of Saturn. This mode is allowed but not fully supported for full pipeline calibration at STScI because of potential contamination of the spectral window by other Echelle orders falling along the width of the MAMA detector. However, our team has successfully built a full calibration pipeline for this mode that has been applied to study the Jovian (non-auroral) and the interplanetary Ly-a emissions (Ben-Jaffel et al., Icarus, 190, 504, 2007; Vincent et al., ApJ, 738, 135, 2011).

-- Orbit 4: Three exposures of Saturn using different modes: one with the STIS/G140M (1222) grating and the long 52x0.1" slit, where the pointing will be the same as in orbits 1-3; and two FUV MAMA images centered on Saturn, one with the 25MAMA clear filter and the other with the F25SRF2 filter. The data will serve to cross-check the derived E140H absolute fluxes with the well calibrated STIS/G140M medium resolution spectroscopy and FUV MAMA imaging. (The F25SRF2 image will be subtracted from the 25MAMA clear image to yield the net Ly-a flux.)

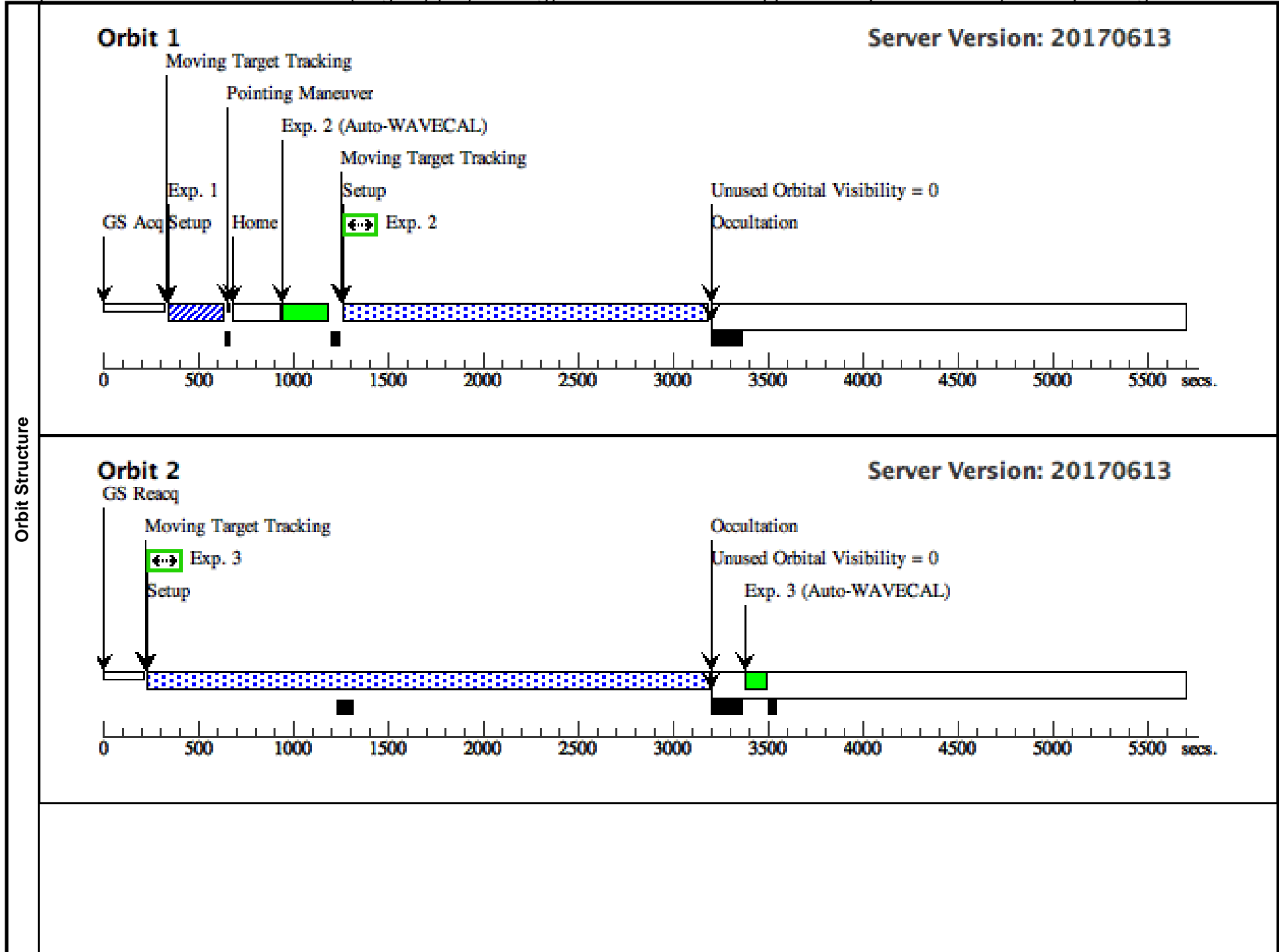
-- Orbit 5: A sky-background exposure in the same high-resolution STIS/E140H, 52x0.5" slit mode used for Saturn, for detailed evaluation of the background.

Proposal 14931 - HST+Cassini-disk (Aug 26) (01) - Energy balance in Saturn's upper atmosphere: Joint Lyman-alpha airglow observa...

Visit	<p>Proposal 14931, HST+Cassini-disk (Aug 26) (01), scheduling Mon Aug 14 21:07:05 GMT 2017</p> <p>Diagnostic Status: Warning</p> <p>Scientific Instruments: STIS/CCD, STIS/FUV-MAMA</p> <p>Special Requirements: BETWEEN 26-AUG-2017:01:45:00 AND 26-AUG-2017:02:40:00</p> <p><i>Comments: Visit 1 coordinated with Cassini observations on August 26, 2017 at 10:34 - 18:34 UT. We have set the HST special timing requirement to expand the Cassini observing window by an additional +/- 12 hours. HST will observe the dayside disk, and Cassini the nightside. HST observing as close as possible to Cassini window will highly enhance the cross-calibration and science return.</i></p>																																									
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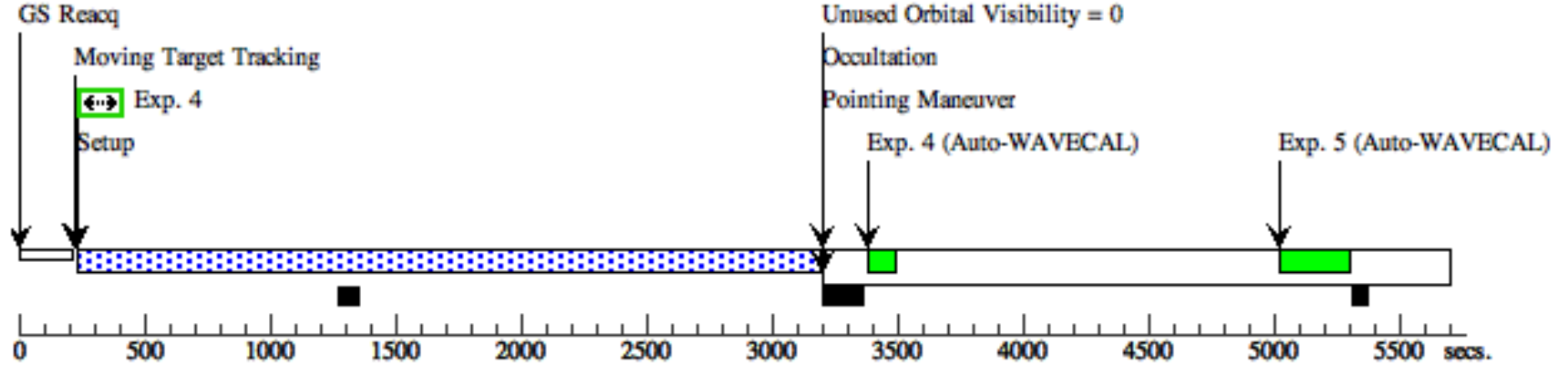
Proposal 14931 - HST+Cassini-disk (Aug 26) (01) - Energy balance in Saturn's upper atmosphere: Joint Lyman-alpha airglow observa...

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Titan-ACQ	(4) TITAN	STIS/CCD, ACQ, F28X50LP	MIRROR	CHECKBOX=9; ACQTYPE=DIFFUSE; DIFFUSE-CENTER=GEOMETRIC-CENTER	GS ACQ SCENARIO BASE1B3		0.5 Secs (0.5 Secs) [==>]	[1]
<i>Comments: The Titan STIS ACQ exposure parameters were taken from the GO# 9745 program (Lemmon et al.) that included STIS ACQ exposures of Titan. See their Visit 02, exposure 1 of TITAN-ANY (observed in Jan 3, 2004).</i>									
2	Saturn-disk E140H orb1 (STIS.sp.99 6659)	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1000	GS ACQ SCENARIO BASE1B3		1880 Secs (1861 Secs) [==>1861.0 Secs]	[1]
<i>Comments: The exposure time is similar to that of previous E140H/52x0.5" exposures of the interplanetary hydrogen (with similar ~1 kR brightness than Saturn) that never had problems with local or global count rates (GO 12800, 12947, 13183, 13628). Since the 52x0.5" slit is not available for ETC runs with E140H, the ETC run provided is for the 6x0.2" slit, for Saturn's 0.1 A wide Ly-a line with 2.e-13 ergs/cm2/s integrated flux, average geocorona, 2500s. (A x10 larger aperture will not exceed global rate limit; STIS.sp.996406.). Please update the slit to 52x0.5", an option that is not available in the APT.</i>									
3	Saturn-disk E140H orb2 (STIS.sp.99 6659)	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1000			2910 Secs (2941 Secs) [==>2941.0 Secs]	[2]
<i>Comments: See comments for Exposure 2 (the 1st E140H exposure).</i>									
4	Saturn-disk E140H orb3 (STIS.sp.99 6659)	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1000			2910 Secs (2898 Secs) [==>2898.0 Secs]	[3]
<i>Comments: See comments for Exposure 2 (the 1st E140H exposure).</i>									
5	Saturn-disk G140M orb4 (STIS.sp.99 6402)	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, 52X0.1	G140M 1222 A	BUFFER-TIME=350			600 Secs (597 Secs) [==>597.0 Secs]	[4]
<i>Comments: ETC run for Saturn's 0.1 A wide Ly-a line with 2.e-13 ergs/cm2/s integrated flux, average geocorona, 2500s.</i>									
6	Saturn-disk CLEAR image orb4	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, 25MAMA	MIRROR	BUFFER-TIME=1000			700 Secs (697 Secs) [==>697.0 Secs]	[4]
<i>Comments: Clear 25MAMA image of Saturn - based on previous imaging of Saturn in the same mode for which 1000s exposures were safe (e.g., GO 6854, GO 13396). For example, for the data-set o4bd04voq (exposure time of 1000 sec), we could observe a global rate of 13088 cts/s, which for the 700 sec required in our program leads to a global rate of 9160 cts/s.</i>									
7	Saturn-disk SrF2 image orb4	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, F25SRF2	MIRROR	BUFFER-TIME=360			910 Secs (907 Secs) [==>907.0 Secs]	[4]
<i>Comments: Continuum F25SRF2 image of Saturn - based on previous imaging of Saturn in the same mode for which 1000s exposures were safe (e.g., GO 6854, GO 13396). For the data-set o4bd04vmq (exposure time of 1000 sec), we could observe a global count rate of 3102 cts/s, which for the 900 sec required in our program leads to a global rate of 2792 cts/s.</i>									



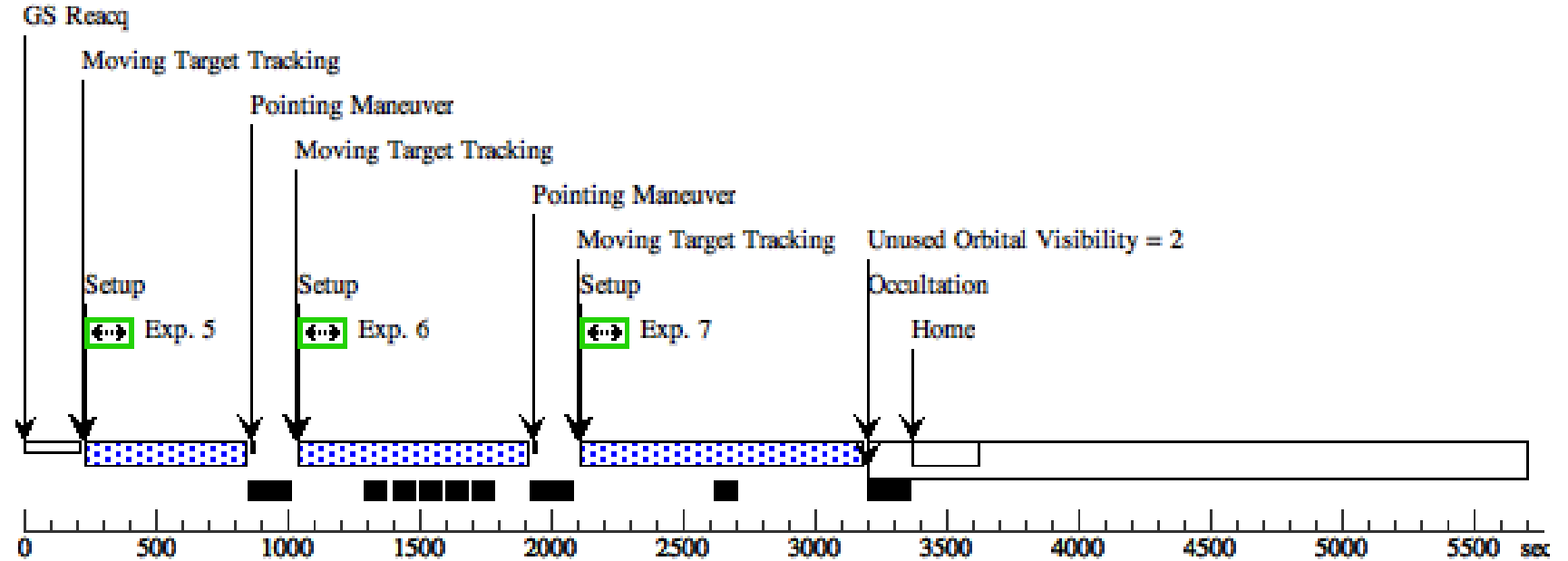
Orbit 3

Server Version: 20170613



Orbit 4

Server Version: 20170613



Proposal 14931 - HST+Cassini-disk (Aug 26) (1A) - Energy balance in Saturn's upper atmosphere: Joint Lyman-alpha airglow observa...

Mon Aug 14 21:07:05 GMT 2017

Visit
Proposal 14931, HST+Cassini-disk (Aug 26) (1A), implementation
Diagnostic Status: Warning
 Scientific Instruments: STIS/FUV-MAMA
 Special Requirements: NOTRACK; AFTER 01 BY 3.9 Orbits TO 4.1 Orbits
Comments: Visit 1 coordinated with Cassini observations on August 26, 2017 at 10:34 - 18:34 UT. We have set the HST special timing requirement to expand the Cassini observing window by an additional +/- 12 hours. HST will observe the dayside disk, and Cassini the nightside. HST observing as close as possible to Cassini window will highly enhance the cross-calibration and science return.

Diagnostics
 (HST+Cassini-disk (Aug 26) (1A)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronagraphy with STIS or COS.

Solar System Targets

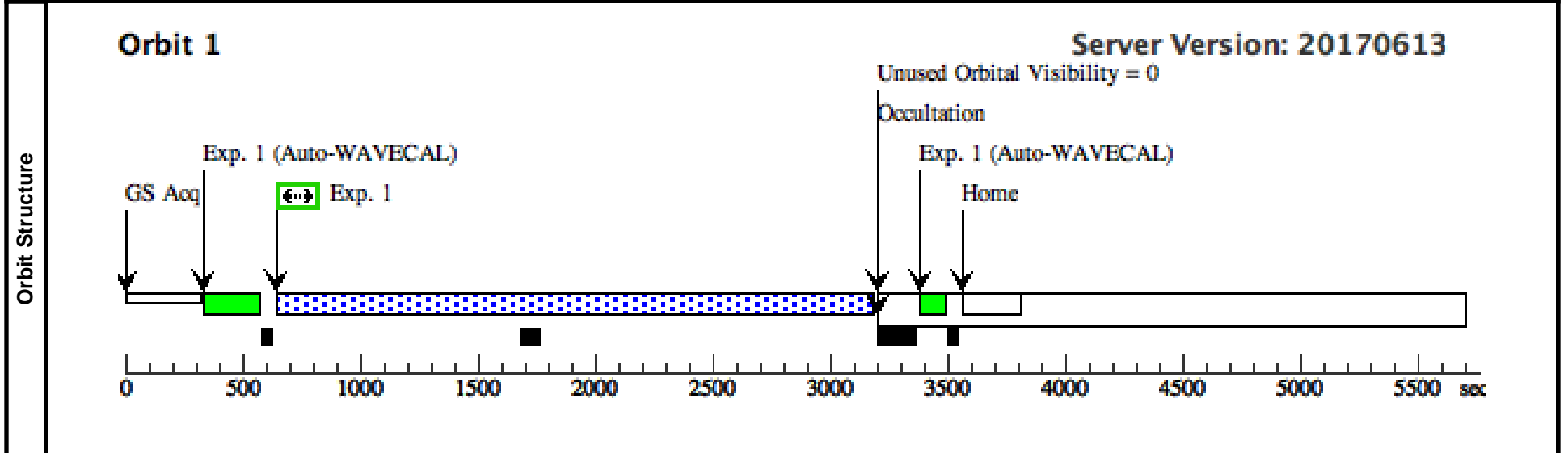
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	SATURN-SKY-OFFSET	STD=SATURN	TYPE=POS_ANGLE,RAD=90,ANG=0,REF=NORTH		NOT ECL P PARTIAL OF SATURN-SKY-OFFSET BY TITAN FROM EARTH, SEP OF SATURN-SKY-OFFSET RHEA FROM EARTH GT 10", SEP OF SATURN-SKY-OFFSET TITAN FROM EARTH GT 10"	HUBBLE

Comments: Stis 52x0.5 long slit 2 arc min from Saturn. Observe Lya line profile from sky background and interplanetary emissions. We list ANG=0 from North but any other angle is fine. Extended=YES

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Sky-offset 20 arcsec (STIS.sp.99 6659)	(3) SATURN-SKY-OFFSET	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=10 00	GS ACQ SCENARI O BASE1B3		2920 Secs (2483 Secs) [=>2483.0 Secs]	[1]

Comments: The exposure time is similar to that of previous E140H/52x0.5" exposures of the interplanetary hydrogen (~1 kR brightness) that never had problems with local or global count rates (GO 12800, 12947, 13183, 13628). Please update slit to 52x0.5", an option that is not available in the APT.



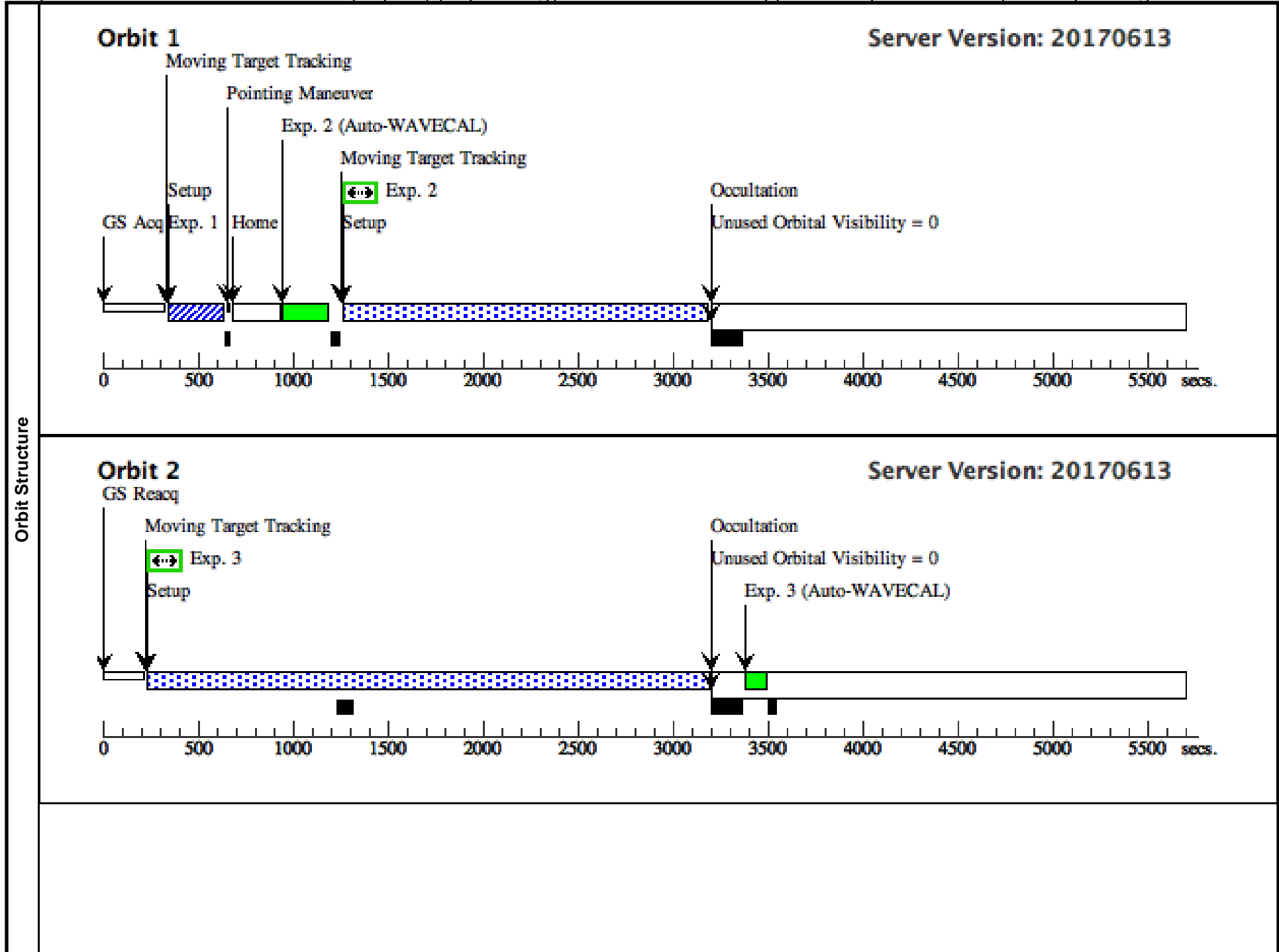
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Visit	<p>Proposal 14931, HST+Cassini-limb (Sep 02) (02), scheduling</p> <p>Diagnostic Status: Warning</p> <p>Scientific Instruments: STIS/CCD, STIS/FUV-MAMA</p> <p>Special Requirements: BETWEEN 01-SEP-2017:23:00:00 AND 02-SEP-2017:00:00:00</p> <p><i>Comments: Visit 2 coordinated with Cassini observations on September 02, 2017 at 01:59 - 08:46 UT. We have set the HST special timing requirement to expand the Cassini observing window by an additional +/- 12 hours. Both HST and Cassini will observe the same bright limb. HST observing as close as possible to the Cassini window will highly enhance the cross-calibration and science return.</i></p>																																																																												
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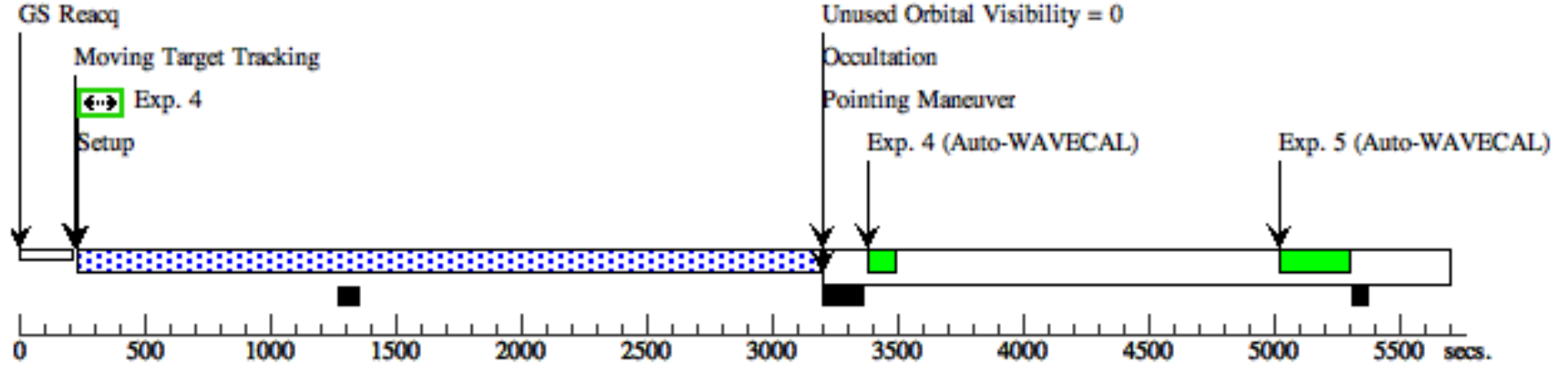
Proposal 14931 - HST+Cassini-limb (Sep 02) (02) - Energy balance in Saturn's upper atmosphere: Joint Lyman-alpha airglow observa...

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1	Titan-ACQ	(4) TITAN	STIS/CCD, ACQ, F28X50LP	MIRROR	CHECKBOX=9; ACQTYPE=DIFFUSE; DIFFUSE-CENTER=GEOMETRIC-CENTER	GS ACQ SCENARIO BASE1B3		0.5 Secs (0.5 Secs) [==>]	[1]
<i>Comments: The Titan STIS ACQ exposure parameters were taken from the GO# 9745 program (Lemmon et al.) that included STIS ACQ exposures of Titan. See their Visit 02, exposure 1 of TITAN-ANY (observed in Jan 3, 2004).</i>									
2	Saturn-limb E140H orb1 (STIS.sp.99 6659)	(2) SATURN-LIMB	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1000	GS ACQ SCENARIO BASE1B3		1880 Secs (1861 Secs) [==>1861.0 Secs]	[1]
<i>Comments: The exposure time is similar to that of previous E140H/52x0.5" exposures of the interplanetary hydrogen (with similar ~1 kR brightness than Saturn) that never had problems with local or global count rates (GO 12800, 12947, 13183, 13628). Since the 52x0.5" slit is not available for ETC runs with E140H, the ETC run provided is for the 6x0.2" slit, for Saturn's 0.1 A wide Ly-a line with 2.e-13 ergs/cm2/s integrated flux, average geocorona, 2500s. (A x10 larger aperture will not exceed global rate limit; STIS.sp.996406.). Please update the slit to 52x0.5", an option that is not available in the APT.</i>									
3	Saturn-limb E140H orb2 (STIS.sp.99 6659)	(2) SATURN-LIMB	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1000			2910 Secs (2941 Secs) [==>2941.0 Secs]	[2]
<i>Comments: See comments for Exposure 2 (the 1st E140H exposure).</i>									
4	Saturn-limb E140H orb3 (STIS.sp.99 6659)	(2) SATURN-LIMB	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1000			2910 Secs (2898 Secs) [==>2898.0 Secs]	[3]
<i>Comments: See comments for Exposure 2 (the 1st E140H exposure).</i>									
5	Saturn-limb G140M orb4 (STIS.sp.99 6402)	(2) SATURN-LIMB	STIS/FUV-MAMA, TIME-TAG, 52X0.1	G140M 1222 A	BUFFER-TIME=350			550 Secs (547 Secs) [==>547.0 Secs]	[4]
<i>Comments: ETC run for Saturn's 0.1 A wide Ly-a line with 2.e-13 ergs/cm2/s integrated flux, average geocorona, 2500s.</i>									
6	Saturn-disk CLEAR image orb4	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, 25MAMA	MIRROR	BUFFER-TIME=1000	GS ACQ SCENARIO BASE1B3		610 Secs (607 Secs) [==>607.0 Secs]	[4]
<i>Comments: Clear 25MAMA image of Saturn - based on previous imaging of Saturn in the same mode for which 1000s exposures were safe (e.g., GO 6854, GO 13396). For example, for the data-set o4bd04voq (exposure time of 1000 sec), we could observe a global rate of 13088 cts/s, which for the 700 sec required in our program leads to a global rate of 9160 cts/s.</i>									
7	Saturn-disk SrF2 image orb4	(1) SATURN-DISK	STIS/FUV-MAMA, TIME-TAG, F25SRF2	MIRROR	BUFFER-TIME=360			787 Secs (784 Secs) [==>784.0 Secs]	[4]
<i>Comments: Continuum F25SRF2 image of Saturn - based on previous imaging of Saturn in the same mode for which 1000s exposures were safe (e.g., GO 6854, GO 13396). For the data-set o4bd04vmq (exposure time of 1000 sec), we could observe a global count rate of 3102 cts/s, which for the 900 sec required in our program leads to a global rate of 2792 cts/s.</i>									



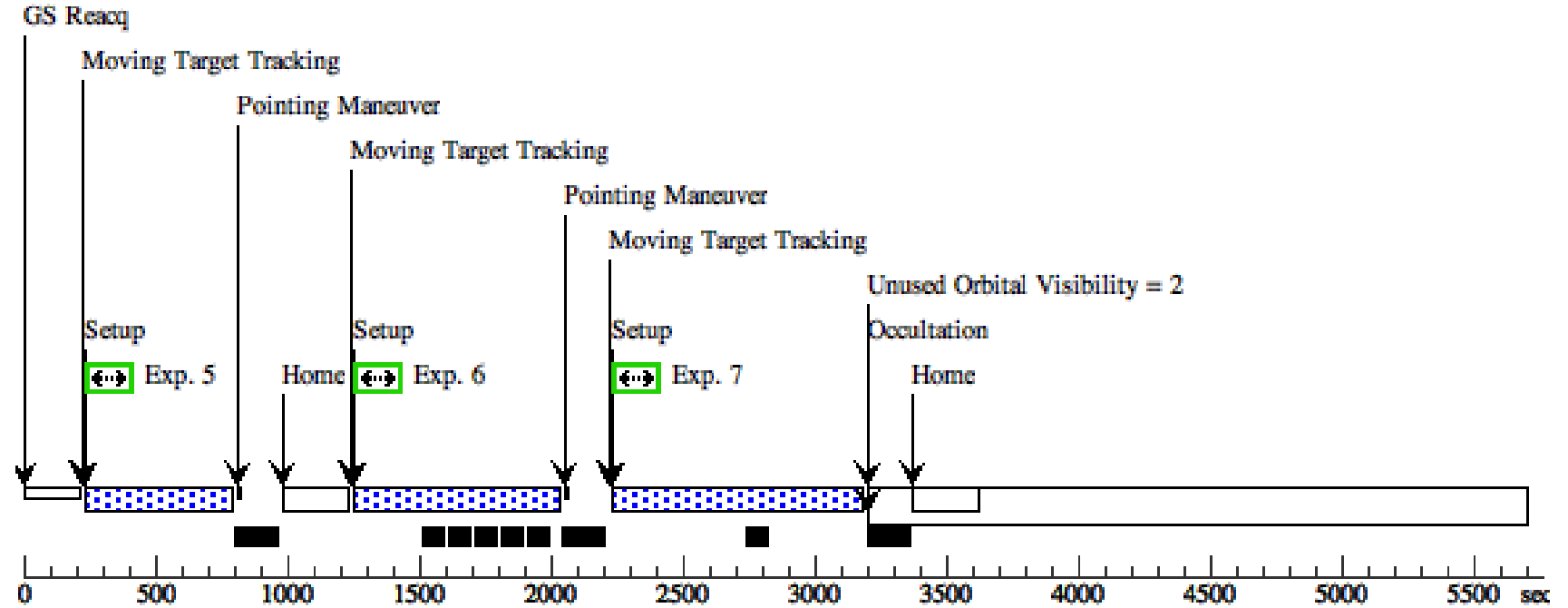
Orbit 3

Server Version: 20170613



Orbit 4

Server Version: 20170613



Proposal 14931 - HST+Cassini-limb (Sep 02) (2A) - Energy balance in Saturn's upper atmosphere: Joint Lyman-alpha airglow observa...

Mon Aug 14 21:07:06 GMT 2017

Visit	Proposal 14931, HST+Cassini-limb (Sep 02) (2A), implementation Diagnostic Status: Warning Scientific Instruments: STIS/FUV-MAMA Special Requirements: NOTRACK; AFTER 02 BY 3.8 Orbits TO 4.2 Orbits <i>Comments: Visit 2 coordinated with Cassini observations on September 02, 2017 at 01:59 - 08:46 UT. We have set the HST special timing requirement to expand the Cassini observing window by an additional +/- 12 hours. Both HST and Cassini will observe the same bright limb. HST observing as close as possible to the Cassini window will highly enhance the cross-calibration and science return.</i>																									
	Diagnosics (HST+Cassini-limb (Sep 02) (2A)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronagraphy with STIS or COS.																									
Solar System Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Level 1</th> <th>Level 2</th> <th>Level 3</th> <th>Window</th> <th>Ephem Center</th> </tr> </thead> <tbody> <tr> <td>(3)</td> <td>SATURN-SKY-OFFSET</td> <td>STD=SATURN</td> <td>TYPE=POS_ANGLE,RAD=90,ANG=0,REF=NORTH</td> <td></td> <td>NOT ECL P PARTIAL OF SATURN-SKY-OFFSET BY TITAN FROM EARTH, SEP OF SATURN-SKY-OFFSET RHEA FROM EARTH GT 10", SEP OF SATURN-SKY-OFFSET TITAN FROM EARTH GT 10"</td> <td>HUBBLE</td> </tr> </tbody> </table>	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center	(3)	SATURN-SKY-OFFSET	STD=SATURN	TYPE=POS_ANGLE,RAD=90,ANG=0,REF=NORTH		NOT ECL P PARTIAL OF SATURN-SKY-OFFSET BY TITAN FROM EARTH, SEP OF SATURN-SKY-OFFSET RHEA FROM EARTH GT 10", SEP OF SATURN-SKY-OFFSET TITAN FROM EARTH GT 10"	HUBBLE	<i>Comments: Stis 52x0.5 long slit 2 arc min from Saturn. Observe Lya line profile from sky background and interplanetary emissions. We list ANG=0 from North but any other angle is fine. Extended=YES</i>										
	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center																			
(3)	SATURN-SKY-OFFSET	STD=SATURN	TYPE=POS_ANGLE,RAD=90,ANG=0,REF=NORTH		NOT ECL P PARTIAL OF SATURN-SKY-OFFSET BY TITAN FROM EARTH, SEP OF SATURN-SKY-OFFSET RHEA FROM EARTH GT 10", SEP OF SATURN-SKY-OFFSET TITAN FROM EARTH GT 10"	HUBBLE																				
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<i>Comments: The exposure time is similar to that of previous E140H/52x0.5" exposures of the interplanetary hydrogen (~1 kR brightness) that never had problems with local or global count rates (GO 12800, 12947, 13183, 13628). Please update slit to 52x0.5", an option that is not available in the APT.</i>																										
Exposures	<p>Orbit 1 Server Version: 20170613</p>																									
	<p>Unused Orbital Visibility = 0</p>																									