



15710 - Simultaneous Lyman-alpha and He I 10830 angstrom observations of HD 189733 b

Cycle: 26, Proposal Category: GO/DD

(Availability Mode: AVAILABLE)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
Dr. Paul Wilson Cauley (PI) (Contact)	University of Colorado at Boulder	paca7401@lasp.colorado.edu
Dr. Vincent Bourrier (CoI) (ESA Member)	Observatoire de Geneve	vincent.bourrier@unige.ch
Prof. Kevin France (CoI)	University of Colorado at Boulder	kevin.france@colorado.edu
Dr. Laura Kreidberg (CoI)	Smithsonian Institution Astrophysical Observatory	laura.kreidberg@cfa.harvard.edu
Dr. Ruth A. Murray-Clay (CoI)	University of California - Santa Cruz	rmc@ucsc.edu
Dr. Antonija Oklopčic (CoI)	Harvard University	antonija.oklopčic@cfa.harvard.edu
Dr. Evgenya L. Shkolnik (CoI)	Arizona State University	shkolnik@asu.edu
Dr. Seth Redfield (CoI)	Wesleyan University	sredfield@wesleyan.edu
Dr. Allison Youngblood (CoI)	University of Colorado at Boulder	allison.a.youngblood@gmail.com
John McCann (CoI)	University of California - Santa Barbara	mccann@ucsb.edu

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) HD-189733	COS/FUV COS/NUV	5	14-Aug-2020 16:00:19.0	yes
Z1	(1) HD-189733	COS/FUV COS/NUV	5	14-Aug-2020 16:00:20.0	yes
H1	(1) HD-189733	COS/FUV COS/NUV	5	14-Aug-2020 16:00:22.0	yes

15 Total Orbits Used

ABSTRACT

Planets with very short orbital periods, or hot planets, are subject to large amounts of stellar radiation which in turn can cause them to evaporate. For Neptune and super-Earth mass planets this mass loss process is important on evolutionary timescales, potentially stripping significant fractions of the atmosphere. To date, however, observations of hot planet evaporation are severely limited and models of the observed signatures are highly uncertain. The evaporated material in the exosphere is typically observed in the wings of the hydrogen Lyman-alpha line, which can only be captured with UV-capable instruments aboard HST, restricting the number of potential targets. Recently, the excited helium line at 10830 angstroms has been shown to be a reliable tracer of extended hot planet atmospheres and has been used to estimate mass loss from the observed targets. He I 10830 angstroms can be observed from the ground, greatly expanding the accessible target pool for studies of hot planet mass loss. In the 2019A observing semester, we were awarded a night to observe the transit of HD 189733 b at He I 10830 angstroms. We propose the first ever simultaneous observations of Lyman-alpha and He I 10830 angstroms around this prototypical hot Jupiter in order to place stronger constraints on its mass loss rate by forcing thermosphere and exosphere models of the simultaneous data to agree. This unique approach will illuminate shortcomings in both the He I and Lyman-alpha models, leading to better mass loss models for targets with only He I 10830 angstrom observations. This is critical due to the large number of He I 10830 transits that will be observed in the near future.

OBSERVING DESCRIPTION

We will use COS with the G130M grating (R~16,000-21,000) with a central wavelength setting of 1291 angstroms (Segment B = 1132-1274 angstroms, Segment A=1291-1433 angstroms) to observe the hydrogen Lyman-alpha line at 1216 angstroms with the goal of detecting absorption in the atmosphere of the hot Jupiter HD 189733 b. We request 5 orbits bracketing the transit of HD 189733 b which begins at UT 10:15 on 07-25-2019. This is the only possible time for the observations as this is the same transit we will be observing from the ground using the spectrograph NIRSPEC on Keck II. Five orbits are necessary in order to adequately sample the out-of-transit stellar Lyman-alpha flux both pre- and post-transit: two orbits sample the transit while the other three occur pre- and post-transit. This mitigates the possibility of the baseline out-of-transit fluxes being contaminated by material that is leading or trailing the planet or stochastic changes in the line flux due to stellar activity.

Although STIS has been the primary instrument for exoplanet Lyman-alpha observations, new work by Bourrier et al. (2018b) has shown that subtracting the COS airglow emission at Lyman-alpha can reliably produce spectra with higher signal-to-noise (SN) than STIS observations. We have performed our own airglow analysis of recent HD 189733 COS observations (Program ID 14767) and found that the resulting Lyman-alpha line profiles are consistent with those obtained by STIS (see Figure 4). In fact, due to the greater efficiency of COS, we find that airglow-subtracted exposures from single orbits, or $t=2700$ seconds, with COS G130M have comparable SN to STIS spectra averaged across $t=8600$ seconds (4 orbits). Thus COS offers a significant SN advantage even accounting for the airglow subtraction.

Our instrument setup will also allow us to analyze a suite of metal lines for absorption in HD 189733 b's atmosphere. This includes, for example, Si III at 1206 angstroms, N V at 1243 angstroms, O I near 1300 angstroms, and C I and O I near 1355 angstroms, some of which have previous marginal detections of in-transit variations (e.g., Bourrier et al. 2013, Ben-Jael & Ballester 2013). Follow-up variability analysis of these lines will be performed with our data set.

The visibility of HD 189733 is ~50 minutes during a single HST orbit. We will observe HD 189733 for the entirety of each orbit with exposure times of 2700 seconds. The COS spectra shown in Figure 4 were observed with similar exposure times, resulting in a SN ~10-20 per dispersion element across the important regions of the Lyman-alpha wings (gray shaded regions in the right panel of Figure 4). HD 189733 has been successfully observed with our setup and is within the brightness limits for the proposed exposure times.

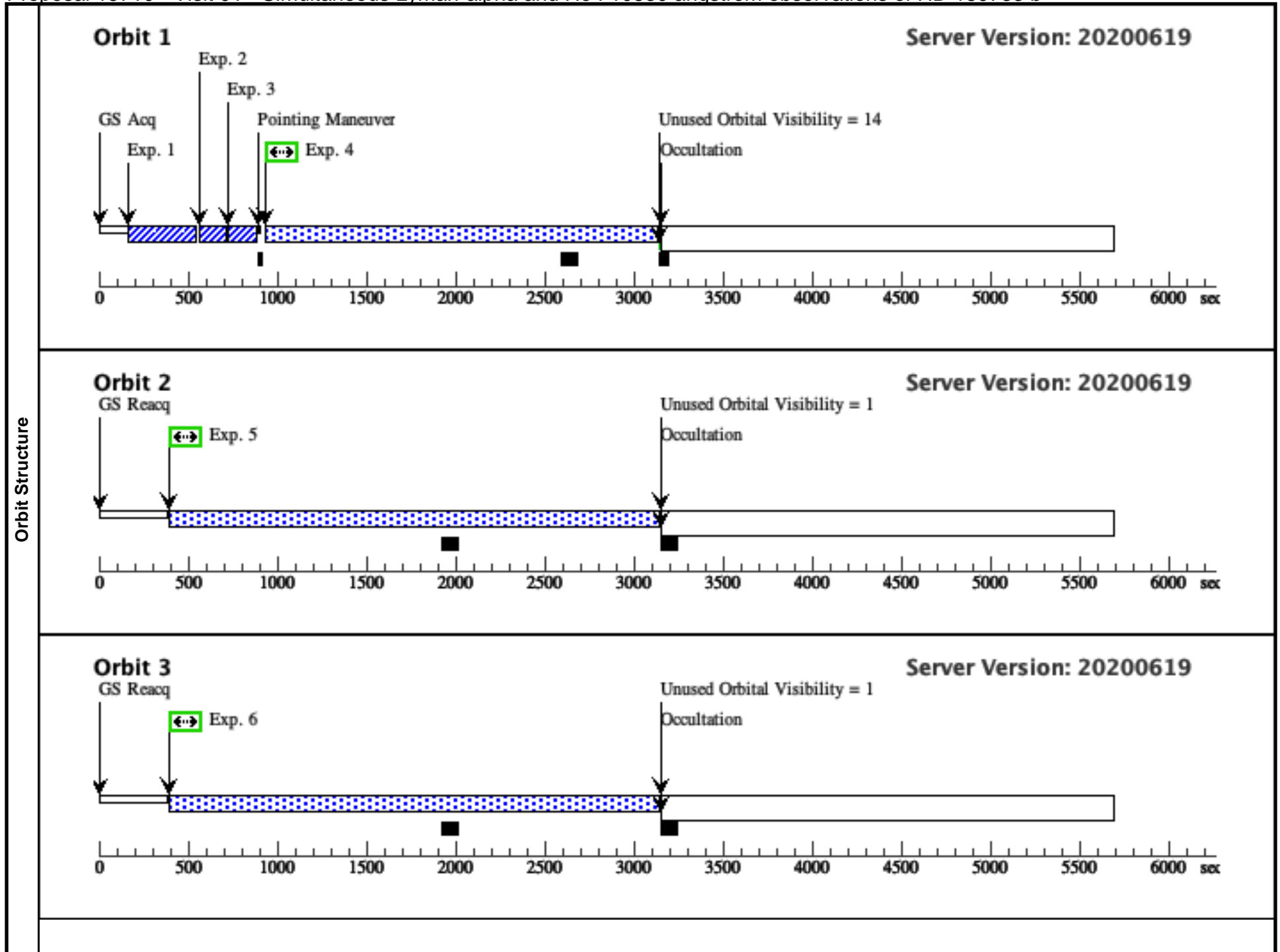
Proposal 15710 - Visit 01 - Simultaneous Lyman-alpha and He I 10830 angstrom observations of HD 189733 b

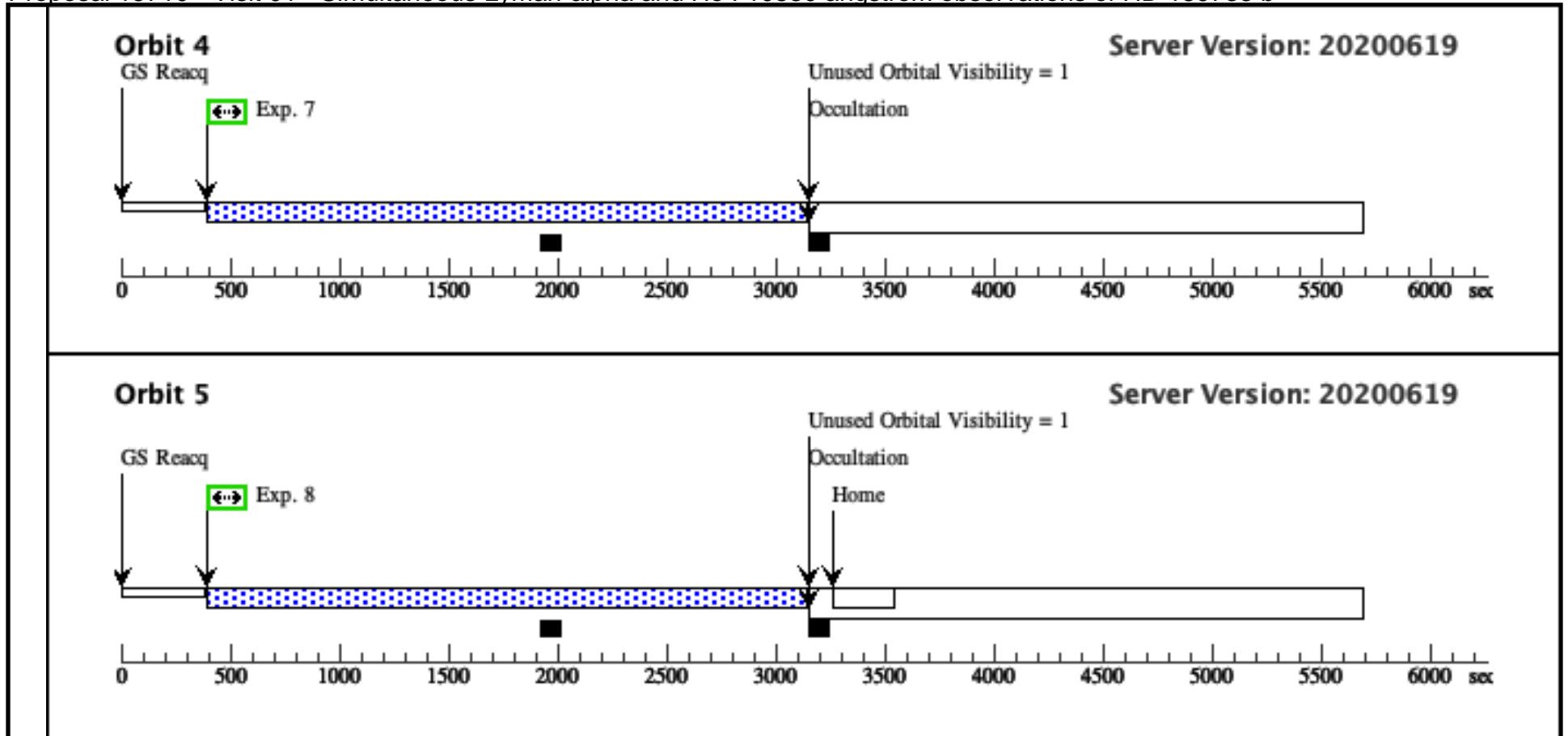
Fri Aug 14 20:00:22 GMT 2020

Visit	<p>Proposal 15710, Visit 01, failed</p> <p>Diagnostic Status: Warning</p> <p>Scientific Instruments: COS/FUV, COS/NUV</p> <p>Special Requirements: ORIENT 245D TO 155 D; BETWEEN 25-JUL-2019:07:00:00 AND 25-JUL-2019:14:30:00</p>					
Diagnostics	<p>(Exposure 1 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.</p> <p>(Exposure 2 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.</p> <p>(Exposure 3 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.</p>					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	HD-189733	RA: 20 00 43.7093 (300.1821221d) Dec: +22 42 35.19 (22.70978d) Equinox: J2000	Proper Motion RA: -2.3805594617473203E-4 sec of time/yr Proper Motion Dec: -0.25022499999067804 arcsec/yr Epoch of Position: 2015.5	V=7.648	Reference Frame: ICRS
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=STAR</i></p> <p><i>Description=[K V-IV]</i></p> <p><i>Extended=NO</i></p>					

Proposal 15710 - Visit 01 - Simultaneous Lyman-alpha and He I 10830 angstrom observations of HD 189733 b

Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) HD-189733	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=2			2 Secs (2 Secs) [==>]	[1]
	2		(1) HD-189733	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A				86.00 Secs (86 Secs) [==>]	[1]
	3		(1) HD-189733	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5.0			2.0 Secs (2 Secs) [==>]	[1]
	4	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2018 Secs (2018 Secs) [==>]	[1]
	5	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2700 Secs (2700 Secs) [==>]	[2]
	6	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2700 Secs (2700 Secs) [==>]	[3]
	7	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2700 Secs (2700 Secs) [==>]	[4]
	8	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2700 Secs (2700 Secs) [==>]	[5]



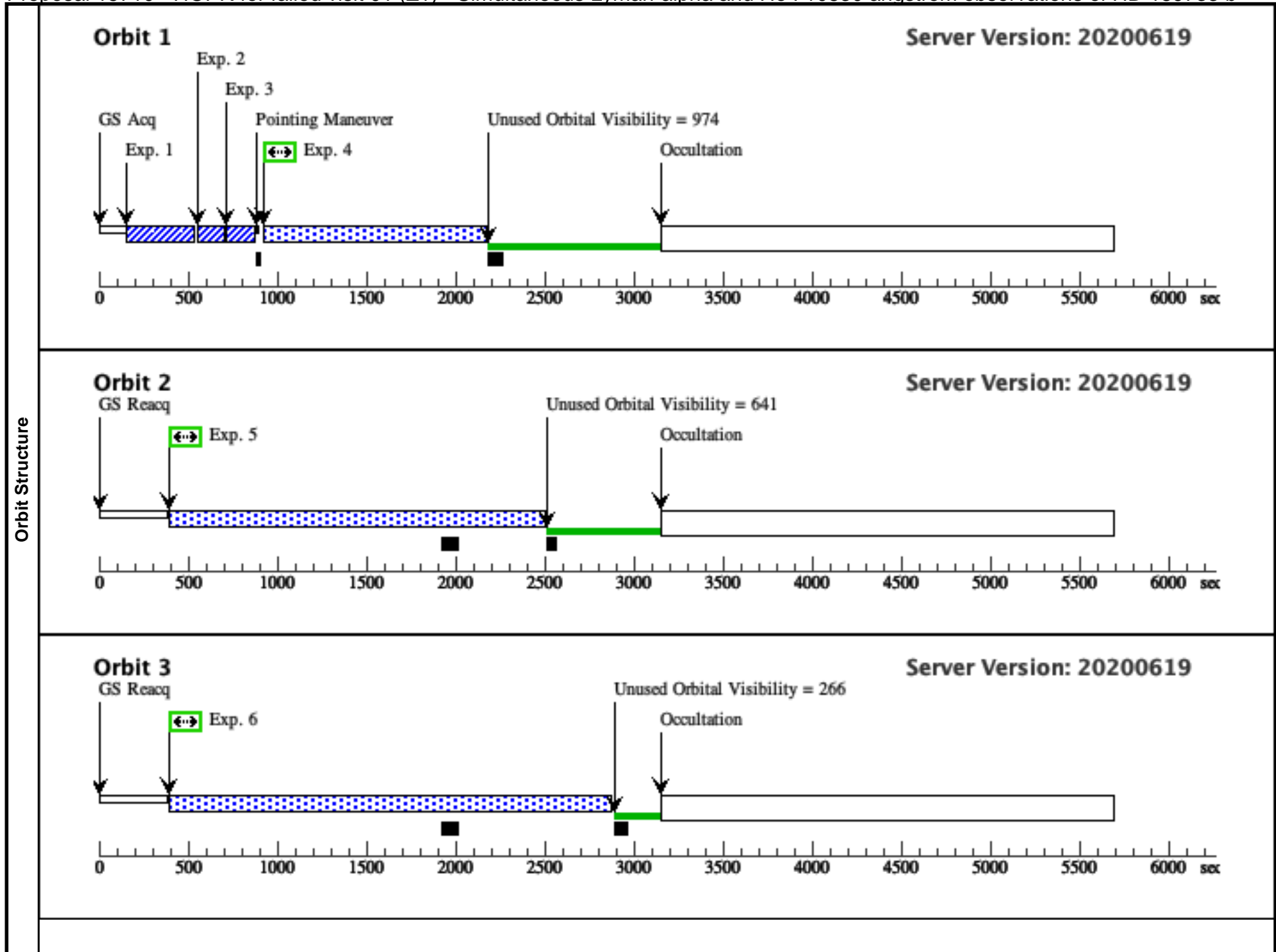


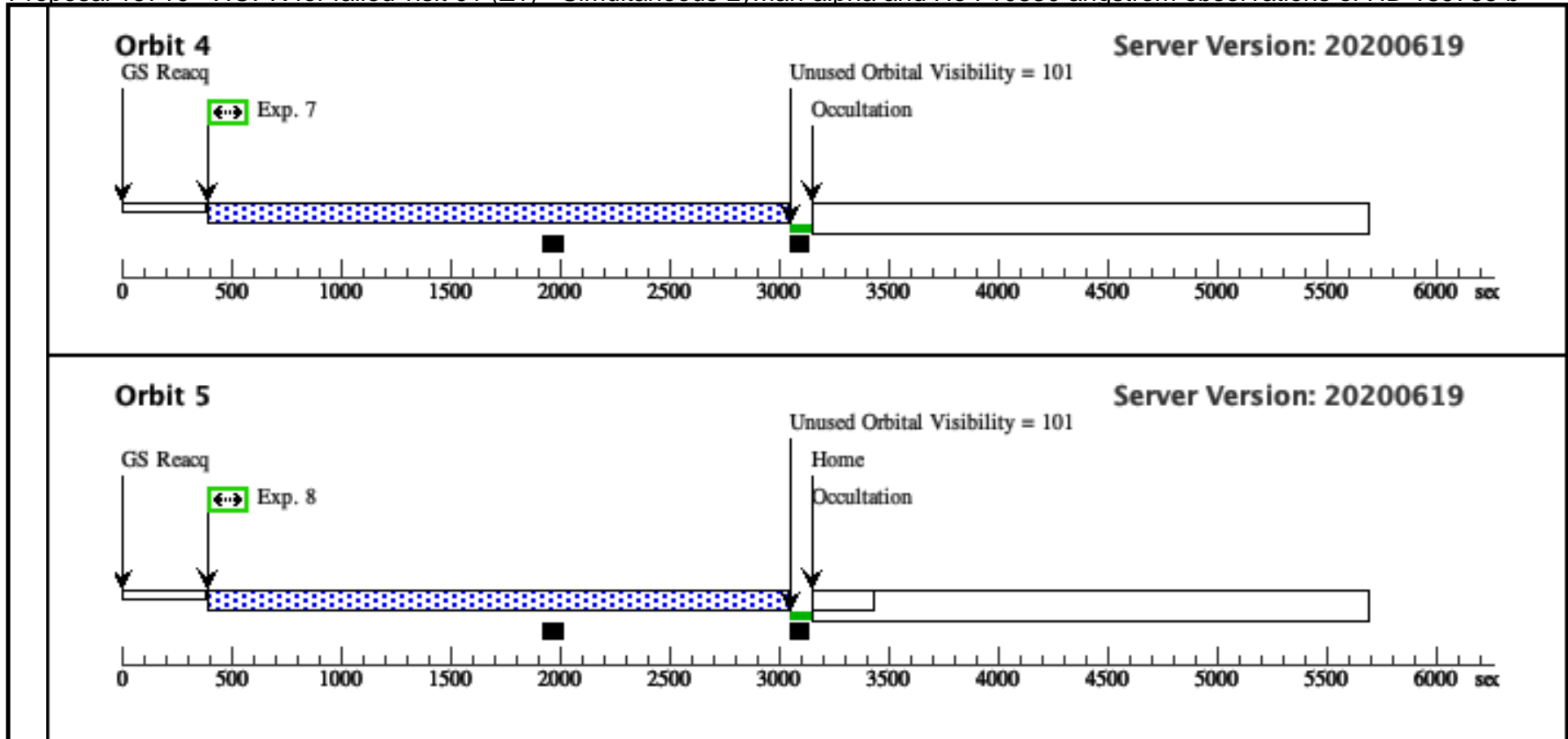
Proposal 15710 - HOPR for failed visit 01 (Z1) - Simultaneous Lyman-alpha and He I 10830 angstrom observations of HD 189733 b

Visit	<p>Proposal 15710, HOPR for failed visit 01 (Z1), failed Fri Aug 14 20:00:23 GMT 2020</p> <p>Diagnostic Status: Warning</p> <p>Scientific Instruments: COS/FUV, COS/NUV</p> <p>Special Requirements: (none)</p>																						
	Diagnostics	<p>(Exposure 1 (HOPR for failed visit 01 (Z1))) Warning (Form): Sensitive exposures should have an ETC run number provided.</p> <p>(Exposure 2 (HOPR for failed visit 01 (Z1))) Warning (Form): Sensitive exposures should have an ETC run number provided.</p> <p>(Exposure 3 (HOPR for failed visit 01 (Z1))) Warning (Form): Sensitive exposures should have an ETC run number provided.</p>																					
Fixed Targets		<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>HD-189733</td> <td> RA: 20 00 43.7093 (300.1821221d) Dec: +22 42 35.19 (22.70978d) Equinox: J2000 </td> <td> Proper Motion RA: -2.3805594617473203E-4 sec of time/yr Proper Motion Dec: -0.25022499999067804 arcsec/yr Epoch of Position: 2015.5 </td> <td>V=7.648</td> <td>Reference Frame: ICRS</td> </tr> <tr> <td colspan="6"> <p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=STAR</i></p> <p><i>Description=[K V-IV]</i></p> <p><i>Extended=NO</i></p> </td> </tr> </tbody> </table>					#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(1)	HD-189733	RA: 20 00 43.7093 (300.1821221d) Dec: +22 42 35.19 (22.70978d) Equinox: J2000	Proper Motion RA: -2.3805594617473203E-4 sec of time/yr Proper Motion Dec: -0.25022499999067804 arcsec/yr Epoch of Position: 2015.5	V=7.648	Reference Frame: ICRS	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=STAR</i></p> <p><i>Description=[K V-IV]</i></p> <p><i>Extended=NO</i></p>				
	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous																	
(1)	HD-189733	RA: 20 00 43.7093 (300.1821221d) Dec: +22 42 35.19 (22.70978d) Equinox: J2000	Proper Motion RA: -2.3805594617473203E-4 sec of time/yr Proper Motion Dec: -0.25022499999067804 arcsec/yr Epoch of Position: 2015.5	V=7.648	Reference Frame: ICRS																		
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=STAR</i></p> <p><i>Description=[K V-IV]</i></p> <p><i>Extended=NO</i></p>																							

Proposal 15710 - HOPR for failed visit 01 (Z1) - Simultaneous Lyman-alpha and He I 10830 angstrom observations of HD 189733 b

Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) HD-189733	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=2	GS ACQ SCENARI O BASE1B3		2 Secs (2 Secs) [==>]	[1]
	2		(1) HD-189733	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A				86.00 Secs (86 Secs) [==>]	[1]
	3		(1) HD-189733	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5.0			2.0 Secs (2 Secs) [==>]	[1]
	4	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			1068 Secs (1068 Secs) [==>]	[1]
	5	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2060 Secs (2060 Secs) [==>]	[2]
	6	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2435 Secs (2435 Secs) [==>]	[3]
	7	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2600 Secs (2600 Secs) [==>]	[4]
	8	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2600 Secs (2600 Secs) [==>]	[5]





Proposal 15710 - HOPR for failed visit Z1 (H1) - Simultaneous Lyman-alpha and He I 10830 angstrom observations of HD 189733 b

Visit	Proposal 15710, HOPR for failed visit Z1 (H1), implementation Fri Aug 14 20:00:23 GMT 2020 Diagnostic Status: Warning Scientific Instruments: COS/FUV, COS/NUV Special Requirements: (none) <i>Comments: This is a HOPR for failed Z1</i>																
	Diagnostics	(Exposure 1 (HOPR for failed visit Z1 (H1))) Warning (Form): Sensitive exposures should have an ETC run number provided. (Exposure 2 (HOPR for failed visit Z1 (H1))) Warning (Form): Sensitive exposures should have an ETC run number provided. (Exposure 3 (HOPR for failed visit Z1 (H1))) Warning (Form): Sensitive exposures should have an ETC run number provided.															
Fixed Targets		<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>HD-189733</td> <td>RA: 20 00 43.7093 (300.1821221d) Dec: +22 42 35.19 (22.70978d) Equinox: J2000</td> <td>Proper Motion RA: -2.3805594617473203E-4 sec of time/yr Proper Motion Dec: -0.25022499999067804 arcsec/yr Epoch of Position: 2015.5</td> <td>V=7.648</td> <td>Reference Frame: ICRS</td> </tr> </tbody> </table> <p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=STAR Description=[K V-IV] Extended=NO</p>					#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(1)	HD-189733	RA: 20 00 43.7093 (300.1821221d) Dec: +22 42 35.19 (22.70978d) Equinox: J2000	Proper Motion RA: -2.3805594617473203E-4 sec of time/yr Proper Motion Dec: -0.25022499999067804 arcsec/yr Epoch of Position: 2015.5	V=7.648
	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous											
(1)	HD-189733	RA: 20 00 43.7093 (300.1821221d) Dec: +22 42 35.19 (22.70978d) Equinox: J2000	Proper Motion RA: -2.3805594617473203E-4 sec of time/yr Proper Motion Dec: -0.25022499999067804 arcsec/yr Epoch of Position: 2015.5	V=7.648	Reference Frame: ICRS												

Proposal 15710 - HOPR for failed visit Z1 (H1) - Simultaneous Lyman-alpha and He I 10830 angstrom observations of HD 189733 b

Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) HD-189733	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=2			2 Secs (2 Secs) [==>]	[1]
	2		(1) HD-189733	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A				86.00 Secs (86 Secs) [==>]	[1]
	3		(1) HD-189733	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=.9; NUM-POS=5.0			2.0 Secs (2 Secs) [==>]	[1]
	4	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			1068 Secs (1068 Secs) [==>]	[1]
	5	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2060 Secs (2060 Secs) [==>]	[2]
	6	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2435 Secs (2435 Secs) [==>]	[3]
	7	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2600 Secs (2600 Secs) [==>]	[4]
8	(COS.sp.135 2193)	(1) HD-189733	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=15 00; SEGMENT=BOTH; FP-POS=3; LIFETIME-POS=L P3			2600 Secs (2600 Secs) [==>]	[5]	

