13323 - Taking the Temperature of Explosive Stellar Flares

Cycle: 21, 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) GJ-1243	COS/NUV	8	20-Aug-2014 21:00:33.0	yes

8 Total Orbits Used

ABSTRACT

State-of-the-art radiative hydrodynamic models which employ solar flare heating mechanisms are not able to produce a key observational component of stellar flares, hot blackbody emission, indicating that there is significant physics missing from our understanding of energy transport and radiation during stellar flares. Efforts to resolve this discrepancy using blue-optical spectrophotometry have proven to be insufficient to accurately constrain the temperature of this blackbody emission and more generally the depth in the atmosphere at which this emission originates. We propose to rectify this shortcoming by using HST/COS to measure the flare blackbody temperatures on the active dM4e star GJ 1243, a star whose frequency of moderate-size flares is extremely well characterized thanks to our Kepler GO-2/3 programs.

OBSERVING DESCRIPTION

We proposed to obtain high-cadence COS NUV (2435-2835A) spectra during stellar flares on the active dM4e flare star GJ 1243, simultaneously with optical data from ground-based telescopes. Our primary goal is to measure the peak of the flare continuum emission in the COS wavelength range and use the ground-based data to characterize flare properties and relate to the optical spectral shape. We will monitor GJ 1243 in time-tag mode continuously within each orbit. The most important aspect of our program is an accurate flux calibration. COS will also provide complementary measurements of the continuum in the FUV, the CIV emission at 1550A and the Mg II h+k lines at 2800A.

-------- Realtime Justification --------

Of critical importance to our observing program is contemporaneous observing from ground-based telescopes, as described in our proposal. We have preferred access to the 3.5m, 1m and 0.5m telescopes at the Apache Point Observatory in New Mexico. In addition, we will apply for ground-based monitoring from Keck, Subaru, McDonald, and Dominion Astrophysical Observatories. We have been awarded 0.5 nights on Keck in late August, and we have been in contact with our HST Program Coordinator to find the optimal time when the HST observations will not be affected by passages through the South Atlantic Anomaly.

--------- Additional Comments ----------

Changes in this Phase II resubmission (2/11/2014):

Based on the optimal coordination with ground-based facilities, we have linked all 8 orbits into a single visit (Visit 01). This also allows us to exchange target acquisition time of the previous Phase II Visit 2/Orbit 1 for science exposure time. We have lifted the previous "BETWEEN" constraints while allowing for "schedulability" of 100, so that we were able to choose the date of August 25th/26th when HST will not pass through the South Atlantic Anomaly. We have changed the "BETWEEN" to reflect the new ground-based scheduling constraints of Visit 01 beginning between UT ~22:10 and 22:30 on August 25th, such that the 8 orbits occur approximately within the time window of 22:20 August 25th and 10:20 August 26th. The highest priority constraint is to have the maximum overlap with Keck, which will observe from approximately UT 5:00 - UT 10:20 during the last 4 orbits of Visit 01.

Previous Phase II submission changes (10/01/2013):
This is a resubmission of our Phase II with an adjusted ACQ algorithm. Our new algorithm of

PEAKXD+PEAKD allows for 850 seconds of monitoring in the first orbit of each visit (an improvement over no monitoring in the first orbit using our previous SEARCH3x3+PEAKXD+PEAKD algorithm). We have made this change because of refined positions and quiescent mangitudes from 2013.4 SWIFT images of GJ1243 obtained from MAST. Note, we still use the 1991.4 positions in this Phase II, but our check against the SWIFT images indicates the uncertainty is closer to ~0.2" instead of the ~0.4" uncertainty from the formal 1991.4 position errors (see comment in Fixed Tarets). We also increased the exposure time in the acquistion to 300 sec, which allows us to achieve the recommended S/N of 40.

Visit

Proposal 13323, Visit 01, scheduling Thu Aug 21 01:00:37 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: COS/NUV

Special Requirements: SCHED 90%; BETWEEN 31-AUG-2014:21:45:00 AND 31-AUG-2014:23:15:00

Comments: Enter some comments.

Diagnostics

(Visit 01) Warning (Form): For the best data quality, it is strongly recommended that all four FP-POS positions be used when observing at a given COS CENWAVE setting.

(Visit 01) Warning (Form): If the target coordinates are not known to 0.4" (or better), an ACQ/SEARCH should precede the ACQ/PEAKXD.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GJ-1243	RA: 19 51 9.1699 (297.7882079d)	Proper Motion RA: +188 mas/yr	V=12.83	Reference Frame: ICRS
		Dec: +46 28 57.95 (46.48276d)	Proper Motion Dec: +266 mas/yr	B=14.47,	
		Equinox: J2000	Parallax: 0.083"	R=12.3,	
			Epoch of Position: 1991.44995	U~15.4	

Comments: The coordinates, coordinate errors, and epoch were obtained from the GSC23DataDisplay using the GSCWebForm and GSC 2.3.3. The hstID=N2HG000199; GSC1ID=0355701335. The total formal uncertainty in the position is 0.4 arcsec (note, we assume that the uncertainty of the RA position is in units of arcsec in the output of the GSCWebForm); therefore, a target star acquisition is necessary. The absolute proper motions were obtained from Lepine & Shara (2005) AJ 129, 1483.

The 1991.4 coordinates were checked against a SWIFT/UVOT/UVW1 image (retrieved from MAST) of GJ 1243 taken on 2013-05-23 (epoch 2013.4). Extrapolated to 2013.4, the 1991.4 coordinates are within 0.06" RA and 0.2" Dec of the coordinates in the SWIFT/UVW1 image. The total uncertainty is < 0.4", which justifies using only a PEAKXD+PEAKD acquisition (deleting the SEARCH3x3 from our previous Phase II).

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Orb1-Target acquisition # 1 (ACQ/PEAKXD) (COS.sa.519303)	(1) GJ-1243	COS/NUV, ACQ/PEAKXD, PSA	G230L 3360 A	STRIPE=DEF			300 Secs (300 Secs) *[==>]*	*[1]*

Comments: 1st part of TA (see comment for Target Acquisition #1/Visit 1).

The uncertainty in RA & Dec are 0.06" and 0.2", respectively (see comment in Fixed Targets), therefore giving a total uncertainty of 0.21". This justifies a target acquisition algorithm.

A non-flaring spectrum of GJ 1243 from 1100-9000 Ang was constructed for the TA calculation: FUV and NUV spectra of AD Leo (a dM3e star; Hawley & Pettersen 1991) scaled to the magnitude of GJ 1243 combined with an optical spectrum of GJ 1243 (Kowalski et al. 2013 ApJS). We used SWIFT/UVOT images of GJ1243 in the UVW1 and UVM2 filters (archive.stsci.edu) to refine the quiescent UV flux.

We considered the possibility of using NUV imaging acquistion, but the count rate limit would be exceeded in the case of an extremely large flare. The use of the BOA and Mirror B allows a very bright flare to occur without the bright limits being exceeded, but the light is diminished too strongly to acheive S/N of 40 in quiescence.

Because the target is intrinsically very faint in the UV during quiescence, a large fraction of the first orbit of each visit must be used for target acquistion. We have scheduled a TA algorithm of ACQ/PEAKXD+ACQ/PEAKD, which gives the best S/N ~40 for each dwell time of 300 seconds. Note, two 3x3 ACQ/SEARCH algorithms only allow for shorter exposure times and this takes up an entire orbit; therefore, the SEARCH was deleted from this version of the Phase II. The COS wavelength position of 3360 gives better S/N (compared to S/N of ~30 for the wavelength position of the science exposures with COS wavelength position 2635) during quiescence because it samples the redder/brighter part of the quiescent continuum. Note that we have conservatively estimated the UV flux of GJ 1243 and any small flares will only increase the S/N for each TA exposure.

We performed an ETC simulation with a conservatively large flare (\Delta u = 4.7 mag; see comments for Orb2-Science Exposure 1) for the 3360 grating and the local+global count rate limits are not exceeded. The buffer time from the ETC (COS.sa.519401) is 200 seconds (2/3 x buffer time is 130 sec), which is less than the exposure time. This would result in the loss of data during the acquisition but the S/N would be far in excess of the required level.

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
2	Orb1-Target acquisition # 2 (ACQ/PEAKD) (COS.sa.519303)	(1) GJ-1243	COS/NUV, ACQ/PEAKD, PSA	G230L 3360 A	CENTER=DEF; NUM-POS=5; STEP-SIZE=0.9			300 Secs (300 Secs) *[==>]*	*[1]*

Comments: 2nd part of TA (see comment for Target Acquisition #1 of Visit 1). We use the recommended parameters of NUM-POS=5, STEP-SIZE=0.9.

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
3	Orb1-Science Exposure #1 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3			3000 Secs (533 Secs) *[==>533.0 Secs]*	*[1]*

Comments: Upper Flux Limits During Giant Flares: We have used the COS online ETC to guarantee that the brightest possible flare emission observed on this star, based on our extensive monitoring of the system with Kepler, does not reach the (local and global) bright limits for irregularly variable sources.

During five months of continuous Kepler monitoring at 1-minute cadence (http://archive.stsci.edu/kepler/preview.php?type=sc&dsn=KPLR009726699-2010203174610), the largest flare observed on GJ 1243 produced a relative increase of 47%. We have spectral data and SDSS u-band data covering a very large flare on the dM4.5e star YZ CMi (Kowalski et al. 2013, ApJS in press). At peak brightness, the estimated relative increase in the Kepler band for the YZ CMi flare is 90%. The SDSS u-band data showed a peak enhancement by 78x, or a 4.7 mag increase. Assuming the same relation between u and Kepler flare fluxes for the GJ 1243 flare, we estimate that the largest u-band enhancement produced over 5 months of Kepler monitoring was \Delta u ~ 4 mag.

To simulate the count rate during this flare at peak, we extrapolate a 12,000 K blackbody normalized to U = 11.4 (implying a flare with \Delta U = 4 magnitudes on GJ 1243) to the wavelength range of COS. Using the ETC, the resulting count rate is 2.6 times lower than the maximum count rate per stripe (12,000 cts/s) limit for irregularly variable sources. Even at twice the peak flux ever observed on this star (\Delta U ~ 4.7 mag), the count level is still 73% of the limit of 12,000 cts/s/stripe (COS.sp.516442). Note, this is far below the global count rate limit (30,000 cts/s) for predictable sources. Although the largest amplitude flare that has been observed on another flare star is the \Delta U = 5.8 mag flare on the dM4.5e star YZ CMi (Kowalski et al. 2009), this large of a flare has never been observed on GJ 1243. Even if a \Delta U = 5.8 mag flare were to occur on GJ 1243, the global count rate of 30,000 cts/s/stripe is not exceeded (COS.sp.516441).

As the CIV and Mg II h+k lines (the only large emission lines in the proposed wavelength ranges) are expected to increase during the flare, we also guarantee that local count rates at these wavelengths are safe. We use the model continuum emission described above for the conservatively large flare (\Delta U ~ 4.7 mag) and we add on the Mg II h and k and C IV line fluxes scaled from the fluxes observed during an extremely large flare on AD Leo, from Hawley et al. (1991). The ETC predicts the brightest pixel is 4.7 cts/s at 2797.8Ang (COS.sp.517295), which is far below the local count rate limit of 70/cts/s/pixel.

Buffer-time justification: We choose a conservative buffer-time of 120 sec. The ETC for a conservatiely large flare (COS.sp.516456) with \Delta U ~ 4.7 mag flare (twice the largest flare observed in 5 months with Kepler) and with a T_flare=12,000K spectrum recommends a buffer time of 230 sec, and 2/3 of this is 150 sec. To allow for slightly larger increases still, a buffer-time of 120 seconds is chosen (which is near the minimum allowable).

FP-POS = 3 is requested because a maximum S/N of 50 in the NUV is sufficient for our purposes and we do not want to coadd data from individual FP-POS settings during our monitoring.

4	Orb2-Science Exposure #2 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3	3000 Secs (2800 Secs) *[==>2800.0 Secs]*	*[2]*

Comments: Upper Flux Limits During Giant Flares: We have used the COS online ETC to guarantee that the brightest possible flare emission observed on this star, based on our extensive monitoring of the system with Kepler, does not reach the (local and global) bright limits for irregularly variable sources.

During five months of continuous Kepler monitoring at 1-minute cadence (http://archive.stsci.edu/kepler/preview.php?type=sc&dsn=KPLR009726699-2010203174610), the largest flare observed on GJ 1243 produced a relative increase of 47%. We have spectral data and SDSS u-band data covering a very large flare on the dM4.5e star YZ CMi (Kowalski et al. 2013, ApJS in press). At peak brightness, the estimated relative increase in the Kepler band for the YZ CMi flare is 90%. The SDSS u-band data showed a peak enhancement by 78x, or a 4.7 mag increase. Assuming the same relation between u and Kepler flare fluxes for the GJ 1243 flare, we estimate that the largest u-band enhancement produced over 5 months of Kepler monitoring was \Delta u ~ 4 mag.

To simulate the count rate during this flare at peak, we extrapolate a 12,000 K blackbody normalized to U = 11.4 (implying a flare with \Delta U = 4 magnitudes on GJ 1243) to the wavelength range of COS. Using the ETC, the resulting count rate is 2.6 times lower than the maximum count rate per stripe (12,000 cts/s) limit for irregularly variable sources. Even at twice the peak flux ever observed on this star (\Delta U ~ 4.7 mag), the count level is still 73% of the limit of 12,000 cts/s/stripe (COS.sp.516442). Note, this is far below the global count rate limit (30,000 cts/s) for predictable sources. Although the largest amplitude flare that has been observed on another flare star is the \Delta U = 5.8 mag flare on the dM4.5e star YZ CMi (Kowalski et al. 2009), this large of a flare has never been observed on GJ 1243. Even if a \Delta U = 5.8 mag flare were to occur on GJ 1243, the global count rate of 30,000 cts/s/stripe is not exceeded (COS.sp.516441).

As the CIV and Mg II h+k lines (the only large emission lines in the proposed wavelength ranges) are expected to increase during the flare, we also guarantee that local count rates at these wavelengths are safe. We use the model continuum emission described above for the conservatively large flare (\Delta U ~ 4.7 mag) and we add on the Mg II h and k and C IV line fluxes scaled from the fluxes observed during an extremely large flare on AD Leo, from Hawley et al. (1991). The ETC predicts the brightest pixel is 4.7 cts/s at 2797.8Ang (COS.sp.517295), which is far below the local count rate limit of 70/cts/s/pixel.

Buffer-time justification: We choose a conservative buffer-time of 120 sec. The ETC for a conservatiely large flare (COS.sp.516456) with \Delta U ~ 4.7 mag flare (twice the largest flare observed in 5 months with Kepler) and with a T_flare=12,000K spectrum recommends a buffer time of 230 sec, and 2/3 of this is 150 sec. To allow for slightly larger increases still, a buffer-time of 120 seconds is chosen (which is near the minimum allowable).

FP-POS = 3 is requested because a maximum S/N of 50 in the NUV is sufficient for our purposes and we do not want to coadd data from individual FP-POS settings during our monitoring.

5	Orb3-Science Exposure #3 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3	3000 Secs (2800 Secs) *[==>2800.0 Secs]*	*[3]*

Comments: See comment for Science Exposure #1 (Visit 01)

6	Orb4-Science Exposure #4 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3	3000 Secs (2800 Secs) *[==>2800.0 Secs]*	*[4]*

Comments: See comment for Science Exposure #1 (Visit 01)

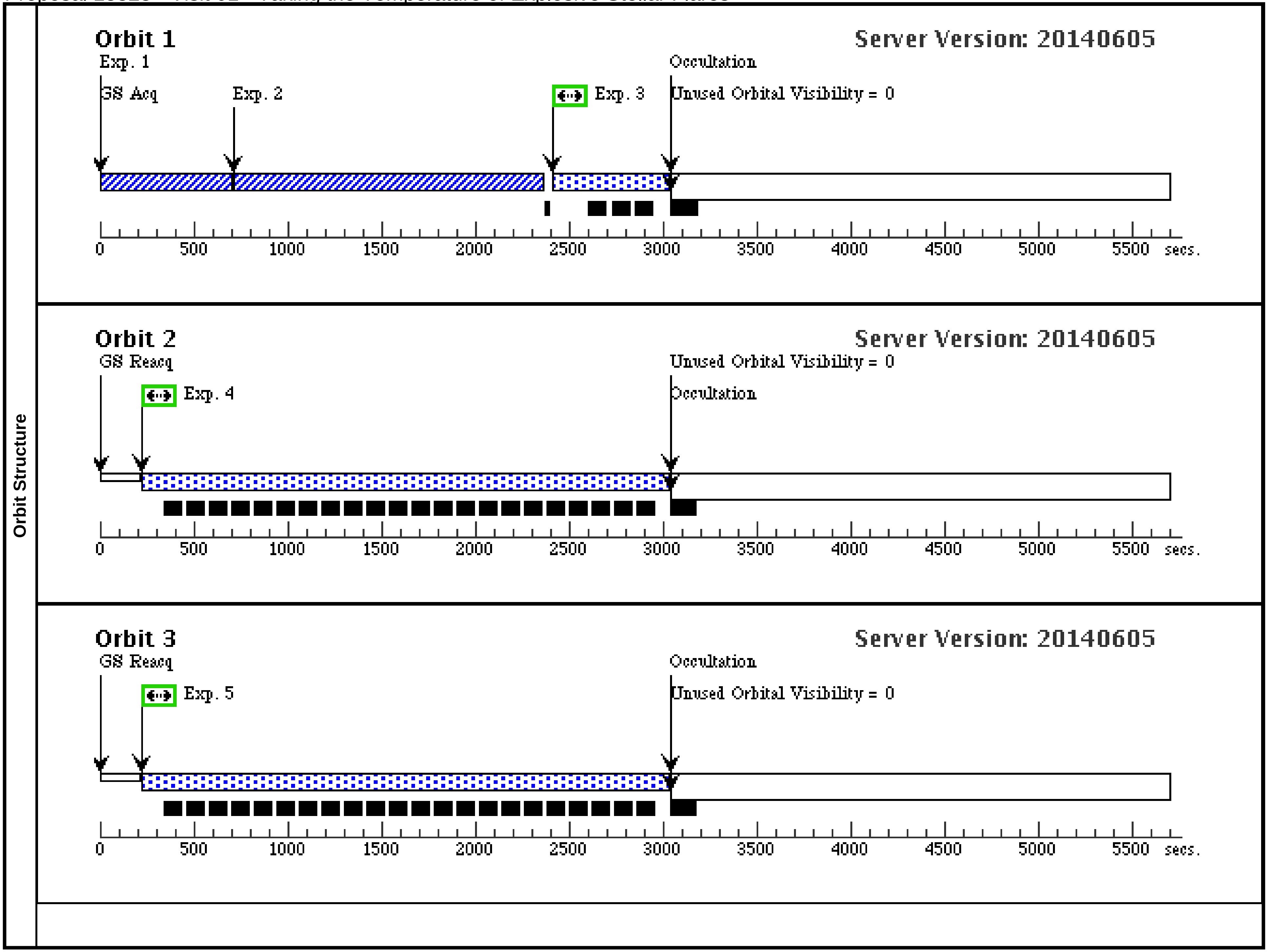
7	Orb5-Science Exposure #5 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3	3000 Secs (2800 Secs) *[==>2800.0 Secs]*	*[5]*

Comments: See comment for Science Exposure #1 (Visit 01)

8	Orb6-Science Exposure #6 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3	3000 Secs (2800 Secs) *[==>2800.0 Secs]*	*[6]*

Comments: See comment for Science Exposure #1 (Visit 01)

	9	Orb7-Science Exposure #7 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3	3000 Secs (2800 Secs) *[==>2800.0 Secs]*	***[7]***
	Comments: See comment for Science Exposure #1 (Visit 01)							
	10	Orb8-Science Exposure #8 (COS.sp.508061)	(1) GJ-1243	COS/NUV, TIME-TAG, PSA	G230L 2635 A	BUFFER-TIME=120; EXTENDED=NO; FLASH=YES; FP-POS=3	3000 Secs (2800 Secs) *[==>2800.0 Secs]*	***[8]***
	Comments: See comment for Science Exposure #1 (Visit 01)							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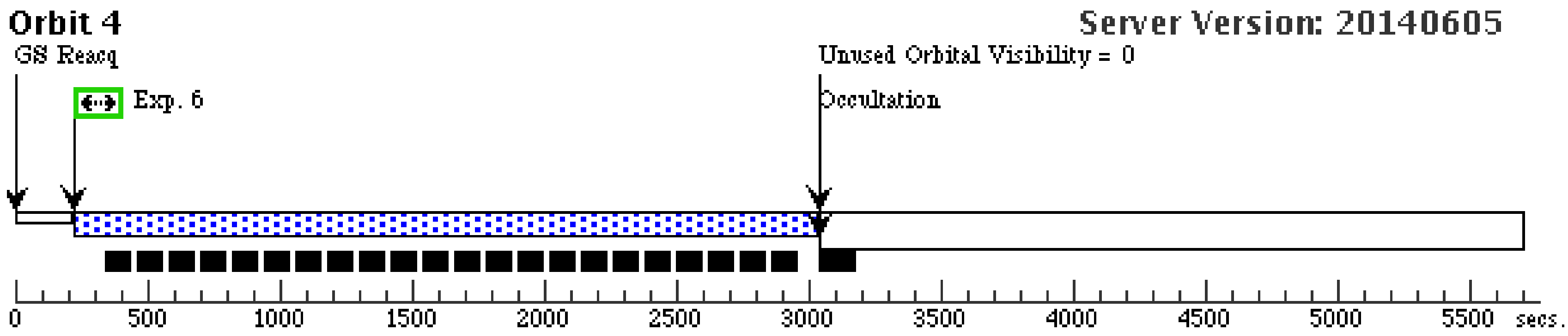
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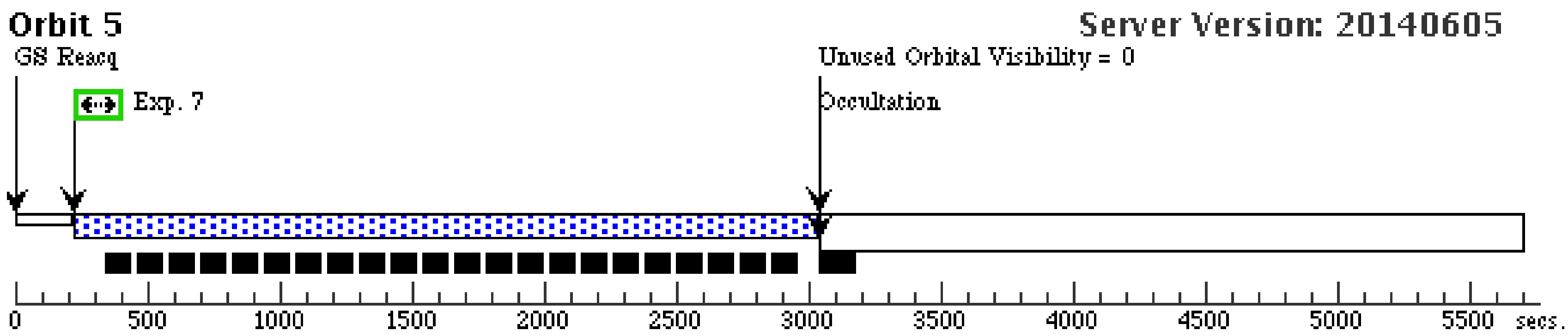
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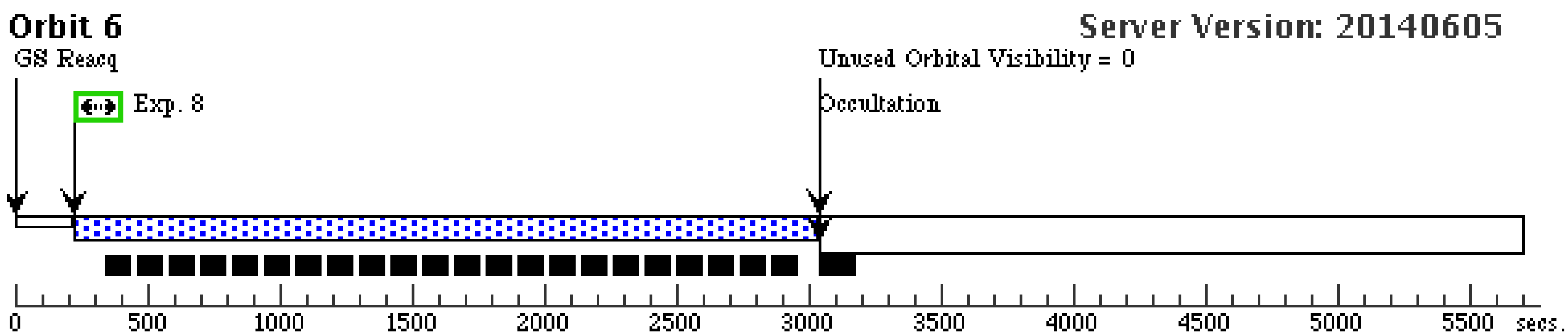
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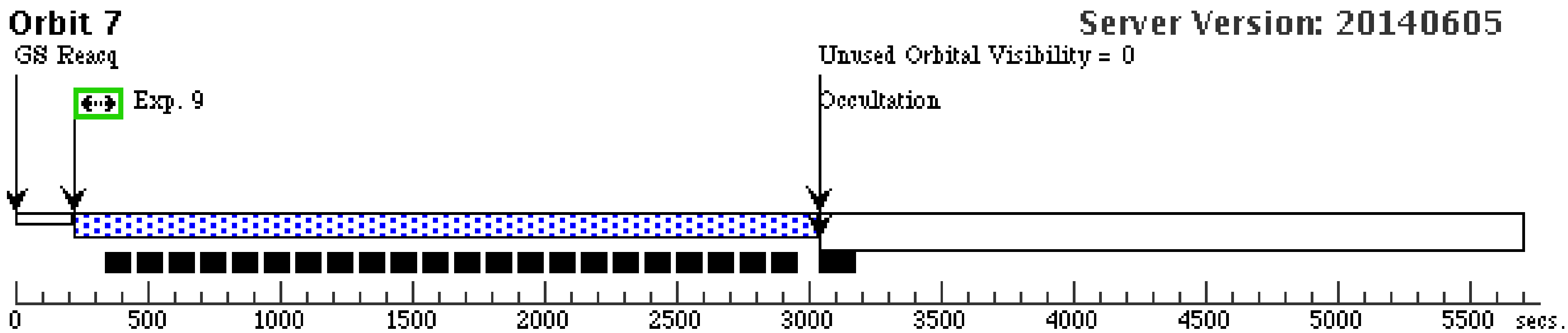
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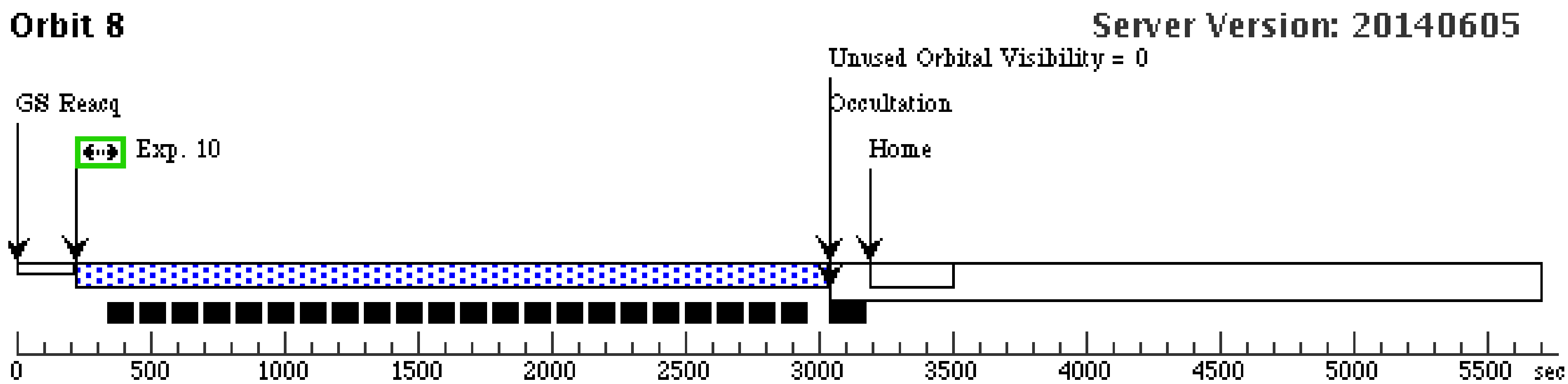
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