11539 - COS-GTO: Io's Atmospheric Response to Eclipse

Cycle: 17, Proposal Category: GTO/COS

(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) IO-EMERGED (3) EUROPA	COS/NUV	2	13-Dec-2011 21:01:08.0	yes
02	(1) IO-EMERGED	COS/NUV	2	13-Dec-2011 21:01:14.0	yes
03	(4) IO-ECLIPSED-HALF-2	COS/FUV	1	13-Dec-2011 21:01:17.0	yes
04	(5) IO-EMERGED-2	COS/FUV	1	13-Dec-2011 21:01:19.0	yes
99	(2) IO-ECLIPSED-HALF (3) EUROPA	COS/FUV COS/NUV	2	13-Dec-2011 21:01:23.0	yes

8 Total Orbits Used

ABSTRACT

We will use four HST orbits to study the response of Io's SO2 atmosphere to eclipse egress in the NUV, and two more orbits to study the FUV auroral response in and after eclipse. Io's atmosphere is supported by a poorly-understood combination of direct volcanic emissions, which exist independently of sunlight, and sublimation of surface SO2 frost, which is expected to be drastically reduced as the frost cools at night or in Jupiter

eclipse. A sublimation supported atmosphere will thus collapse in Jupiter eclipse, and the degree of atmospheric collapse can be used to determine the relative importance of volcanic and sublimation support. The NUV observations will use the COS G225M grating to obtain disk-integrated observations of four SO2 absorption bands, which can be used to determine SO2 atmospheric density. We cannot observe the SO2 atmosphere in eclipse, but we can observe Io as soon as it re-emerges into sunlight to watch the atmosphere recover. This experiment has been done before with FOS, with inconclusive results, but the improved sensitivity of COS will allow shorter exposures, allowing us to investigate the few minutes after eclipse, when the most diagnostic post-eclipse response is expected. G225M will provide a spectral resolution of about 0.8 A for Io's 1" diameter disk, easily resolving the 10 A wide SO2 bands, and will provide a S/N of 27 in 3 minutes (the time taken for Io to emerge) when binned to 2 A resolution, allowing good sensitivity to any post-eclipse atmospheric changes. We plan to observe two eclipse reappearances, using two orbits for each, in order to look for long-term (2-hour) as well as short-term (few minute) changes, and to check the reproducibility of any effects seen.
We will also observe the response of Io's FUV auroral emissions to Io eclipse, exploiting the high sensitivity of COS to obtain higher time resolution than has previously been possible. Though the bulk SO2 atmosphere cannot be observed in eclipse, FUV auroral emissions from neutral O and S can be observed, and their brightness can be modeled to give bulk atmospheric density (Saur and Strobel 2004). We will also observe a single eclipse egress with the G130M grating at 1300 A, to look for the brightness variation of the 1304 and 1356 A OI and 1389 and 1429 A SI lines for comparison with models.

OBSERVING DESCRIPTION

We will use four HST orbits to observe Io during and after eclipse egress in the NUV, and two more orbits to observe in the FUV in and after eclipse. The NUV observations will use the COS G225M grating to obtain disk-integrated observations of two eclipse reappearances, using two orbits for each. In the FUV, We will observe a single eclipse egress with the G130M grating at 1300 A.
The observing window for this observation is in Fall 2009. If by that time targeting for COS observations has been improved to the point where blind pointing is reliable, we can omit the acquisition on Europa, and gain time for science observations or to improve schedulability. The FUV observation currently uses one orbit purley for acquisition, so two separate orbits of science observations could be done without a separate acquisition on Europa.

Proposal 11539 - Visit 01 - COS-GTO: Io's Atmospheric Response to Eclipse

Visit

Proposal 11539, Visit 01, scheduled Wed Dec 14 02:01:28 GMT 2011

Diagnostic Status: Warning

Scientific Instruments: COS/NUV

Special Requirements: (none)

Comments: Acquire on Europa while Io is in eclipse, then offset to Io for NUV spectra.
The observing window for this observation is in Fall 2009. If by that time targeting for COS observations has been improved to the point where ACQ/SEARCH acquisitions are not necessary, this might change our strategy, depending on how much the acquisition time can be shortened. If we can put Io in the COS aperture without doing a Europa offset acquisition that would be even better, and would ease schedulability and provide more time for the science exposures.

Diagnostics

(Visit 01) Warning (Orbit Planner): VISIBILITY OVERRUN

(Visit 01) Warning (Orbit Planner): VISIBILITY OVERRUN

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	IO-EMERGED	STD=JUPITER	STD=IO		OLG OF IO-EMERGED FROM SUN BETWEEN 8.0 27.0, SEP OF IO-EMERGED JUPITER FROM EARTH GT 14.5"	EARTH

Comments: Override default window SEP of IO from JUPITER, to allow observing Io near eclipse.
OLG of Io defined from Sun provides position relative to eclipse -- umbral eclipse ends very near 9.5 degrees, with partial umbral eclipse covering about 0.4 degrees (3 minutes).
Obs should begin during partial umbral eclipse, continuing for 150 minutes (2 orbits) minus acq time (26 minutes, see visit 1) = 17.5 degrees for Io's 1.769 day orbit. add 10 minutes = 1.4 degrees to beginning to aid schedulability.
Start: 9.5-1.5 = 8.0
End: 9.5+17.5 = 27.0

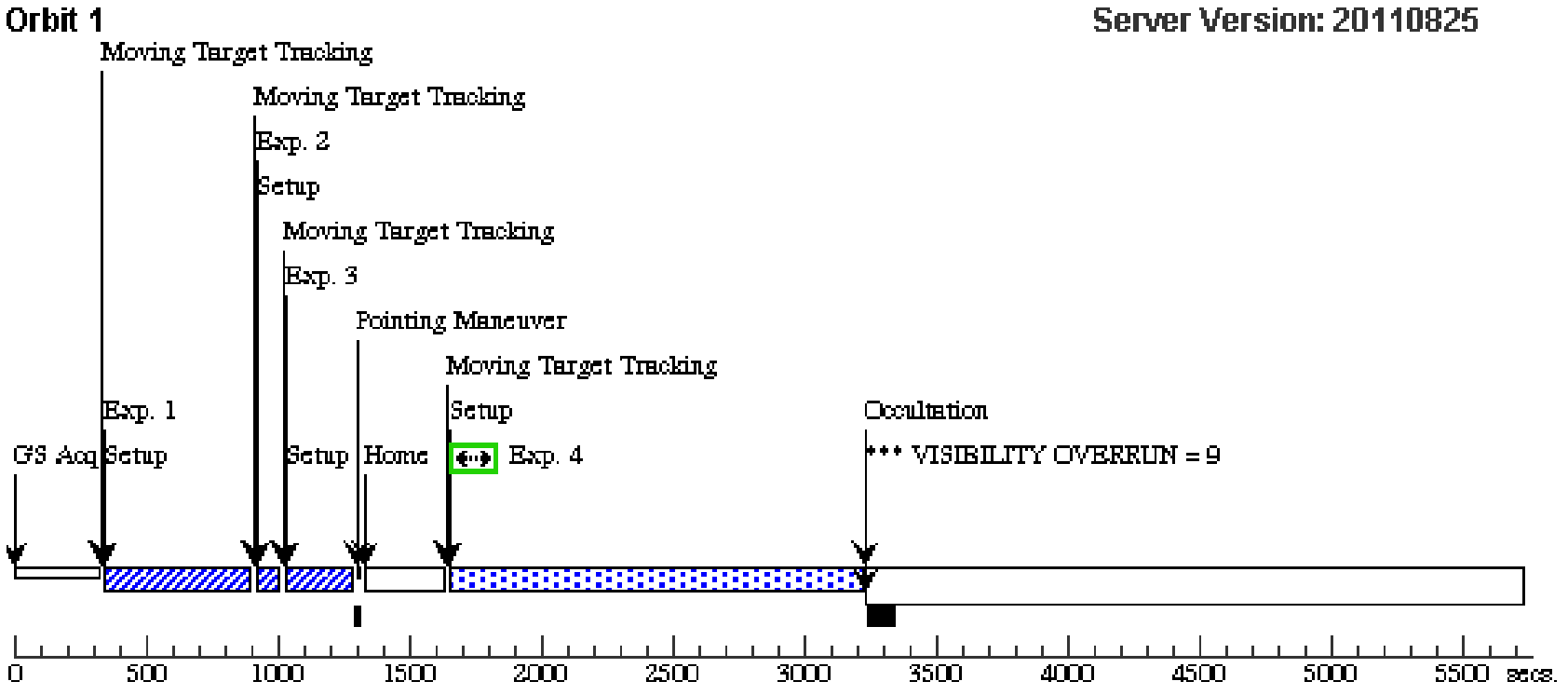
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	EUROPA	STD=JUPITER	STD=EUROPA		SEP OF IO EUROPA FROM EARTH LT 118", SEP OF EUROPA JUPITER FROM EARTH GT 15"	EARTH

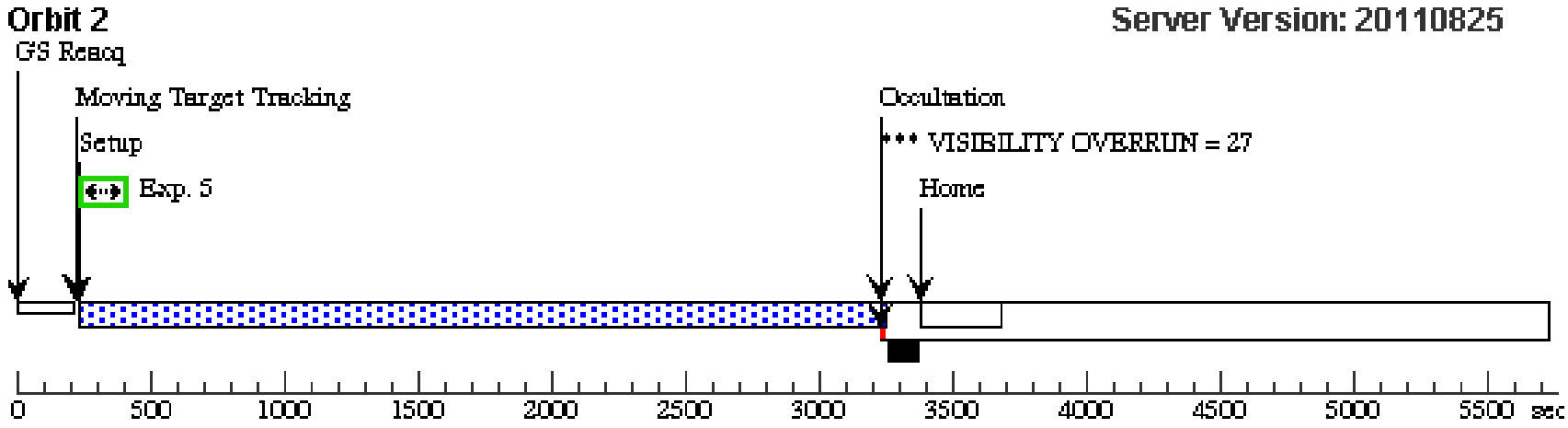
Comments: Use Europa since we can't acquire on Io when in eclipse (too dim)
NUV spectral acq target -- too bright for imaging acq. Must be within max offset of 120" from science target (Io).
Override default window SEP of Europa from JUPITER, to allow more available acq windows.
albedo at 2700Å is 0.45x visible albedo

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(3) EUROPA	COS/NUV, ACQ/SEARCH, PSA	G285M 2719 A	SCAN-SIZE=3			5 Secs *[==>]*	 ***[1]***
Comments: Spectroscopic ACQ ETC: COS77816 *use effective mV = 6.6 (based on albedo = 0.3 near 2700Å instead of 0.67 in visible; true mV = 5.7)* *Brightest and dimmest estimates (+/- 0.5 mags): COS77821, COS77823* *under 1s required for S/N = 40 in all cases, without exceeding count rate limit*									
2		(3) EUROPA	COS/NUV, ACQ/PEAKXD, PSA	G285M 2719 A				5 Secs *[==>]*	 ***[1]***
Comments: Spectroscopic ACQ ETC: COS94545 *use effective mV = 6.6 (based on albedo = 0.3 near 2700Å instead of 0.67 in visible; true mV = 5.7)* *Brightest and dimmest estimates (+/- 0.5 mags): COS94546, COS94547* *under 1s required for S/N = 40 in all cases, without exceeding count rate limit*									
3		(3) EUROPA	COS/NUV, ACQ/PEAKD, PSA	G285M 2719 A	NUM-POS=7.0; STEP-SIZE=1.2			5 Secs *[==>]*	 ***[1]***
4		(1) IO-EMERGED	COS/NUV, TIME-TAG, PSA	G225M 2217 A	BUFFER-TIME=1303			1303 Secs *[==>]*	 ***[1]***
Comments: ETC: COS93872 gives buffer time = 2/3 of 5479s *based on Io effective mV = 9.0 in this waveband* *We do not vary FP-POS because we are looking for time variability and require the instrument configuration to be stable.*									
5		(1) IO-EMERGED	COS/NUV, TIME-TAG, PSA	G225M 2217 A	BUFFER-TIME=3000			3001 Secs *[==>]*	 ***[2]***
Comments: We do not vary FP-POS because we are looking for time variability and require the instrument configuration to be stable.									

Orbit Structure





Proposal 11539 - Visit 02 - COS-GTO: Io's Atmospheric Response to Eclipse

Visit

Proposal 11539, Visit 02, completed Wed Dec 14 02:01:30 GMT 2011

Diagnostic Status: Warning

Scientific Instruments: COS/NUV

Special Requirements: BETWEEN 05-DEC-2011:06:46:00 AND 05-DEC-2011:06:50:00

Comments: Acquire on Europa while Io is in eclipse, then offset to Io for NUV spectra.
The observing window for this observation is in Fall 2009. If by that time targeting for COS observations has been improved to the point where ACQ/SEARCH acquisitions are not necessary, this might change our strategy, depending on how much the acquisition time can be shortened. If we can put Io in the COS aperture without doing a Europa offset acquisition that would be even better, and would ease schedulability and provide more time for the science exposures.

Diagnostics

(Visit 02) Warning (Orbit Planner): VISIBILITY OVERRUN

(Visit 02) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	IO-EMERGED	STD=JUPITER	STD=IO		OLG OF IO-EMERGED FROM SUN BETWEEN 8.0 27.0, SEP OF IO-EMERGED JUPITER FROM EARTH GT 14.5"	EARTH

Comments: Override default window SEP of IO from JUPITER, to allow observing Io near eclipse.
OLG of Io defined from Sun provides position relative to eclipse -- umbral eclipse ends very near 9.5 degrees, with partial umbral eclipse covering about 0.4 degrees (3 minutes).
Obs should begin during partial umbral eclipse, continuing for 150 minutes (2 orbits) minus acq time (26 minutes, see visit 1) = 17.5 degrees for Io's 1.769 day orbit. add 10 minutes = 1.4 degrees to beginning to aid schedulability.
Start: 9.5-1.5 = 8.0
End: 9.5+17.5 = 27.0

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) IO-EMERGED	COS/NUV, TIME-TAG, PSA	G225M 2217 A	BUFFER-TIME=550			1200 Secs *[==>]*	 ***[1]***

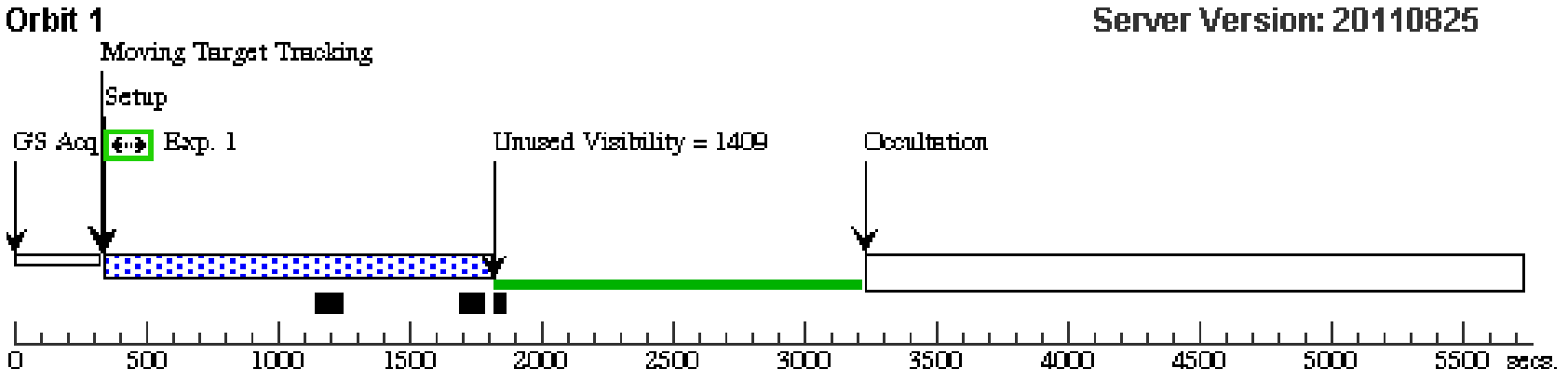
Comments: ETC: COS93872 gives buffer time = 2/3 of 5479s
based on Io effective mV = 9.0 in this waveband

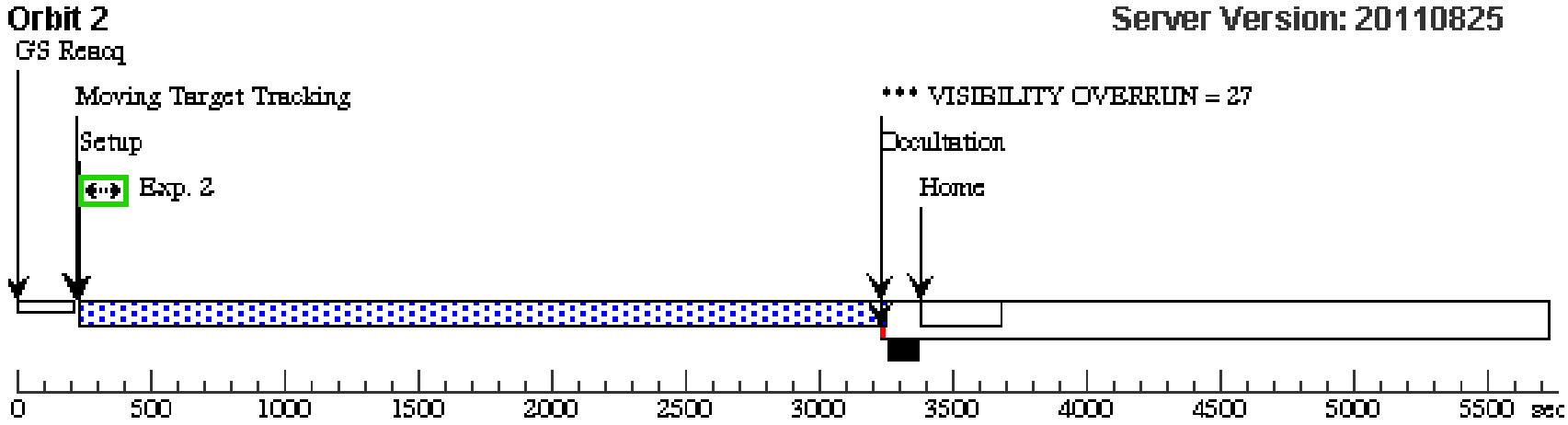
We do not vary FP-POS because we are looking for time variability and require the instrument configuration to be stable.

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
2		(1) IO-EMERGED	COS/NUV, TIME-TAG, PSA	G225M 2217 A	BUFFER-TIME=3000			3001 Secs *[==>]*	 ***[2]***

Comments: We do not vary FP-POS because we are looking for time variability and require the instrument configuration to be stable.

Orbit Structure





Visit

Proposal 11539, Visit 03, implementation Wed Dec 14 02:01:30 GMT 2011

Diagnostic Status: Warning

Scientific Instruments: COS/FUV

Special Requirements: (none)

Comments: We are intentionally using blind acquisition

This visit observes Io immediately after eclipse, overlapping in orbital longitude, and with similar Jupiter System III longitude, to visit 4

Diagnostics

(Visit 03) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(4)	IO-ECLIPSED-HALF-2	STD=JUPITER	STD=IO		OLG OF IO FROM SUN BETWEEN 8.6 16.5, CML OF JUPITER FROM IO BETWEEN 130 250	EARTH

Comments: Intended to start at about eclipse emergence (mid-time is subsolar longitude 9.5 in January 2012) and provide 55 minutes of total coverage. Longitude coverage will overlap with IO-EMERGED-2
Want to start withing 5 minutes either side of eclipse emergence midtime, the remainder with Io emerged
Also require System III longitude of Io 130 and 190 degrees to control the illumination of Io by the magnetosphere.

Other options are System III longitude of 200 - 245 or System III longitude 270 - 315, but if these are chosen, IO-EMERGED-2 should have the same System III longitude constraints

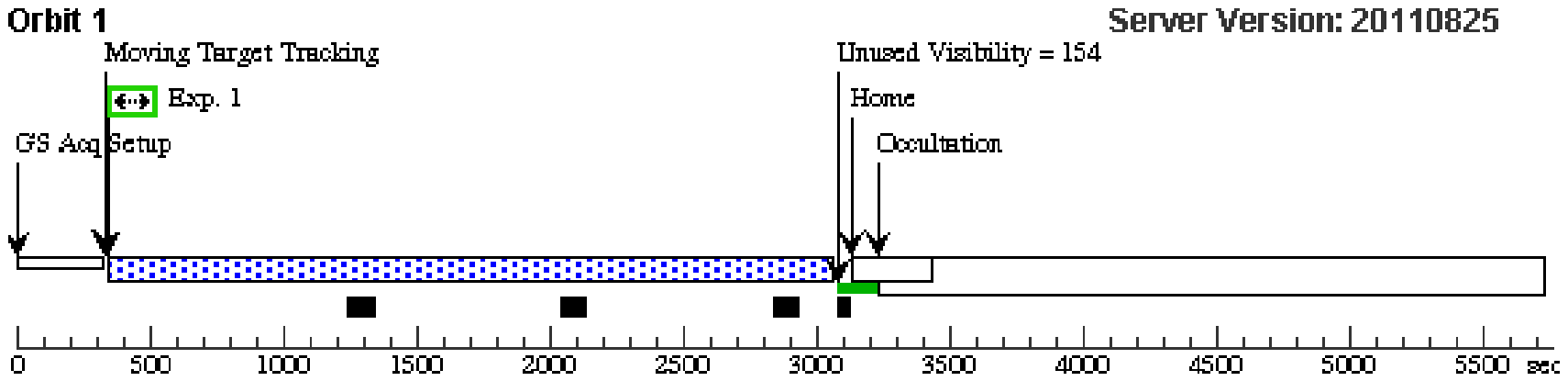
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(4) IO-ECLIPSED-HALF-2	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=800; FP-POS=1	GS ACQ SCENARIO BASE1B3		2600 Secs *[==>]*	*[1]*

Comments: ETC: COS78468 Used 3 strongest lines in this waveband (excluding Lyman alpha) from HST/FOS measurements by Clarke et al 1994, JGR 99., along with high airglow.
Gives buffer time of 2/3 of 2919. We decrease this to 800s to allow for continuum or scatter.

The grating setting is chosen to detect the Io emission lines at 1256, 1304, 1356, 1389, and 1429 A. We do not vary FP-POS because we are looking for time variability and thus prefer to not change the instruments settings during the exposure. HOWEVER we should choose the best single FP-POS value after launch, to avoid (if possible) putting emission lines of interest on known problem areas of the detector.

Orbit Structure



Visit

Proposal 11539, Visit 04, implementation Wed Dec 14 02:01:31 GMT 2011

Diagnostic Status: Warning

Scientific Instruments: COS/FUV

Special Requirements: (none)

Comments: We are intentionally using blind acquisition

This visit covers a period starting ~25 - 40 minutes after eclipse emergence, overlapping in orbital longitude, and with similar Jupiter System III longitude, to visit 3

Diagnostics

(Visit 04) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(5)	IO-EMERGED-2	STD=JUPITER	STD=IO		OLG OF IO FROM SUN BETWEEN 12.0 23.0, CML OF JUPITER FROM IO BETWEEN 130 190	EARTH

Comments: Intended to start at about 25 - 40 minutes after eclipse emergence (mid-time of emergence is subsolar longitude 9.5 in January 2012) and provide 55 minutes of total coverage. Longitude coverage will overlap with IO-ECLIPSED-HALF-2.
Also require System III longitude of Io 130 and 190 degrees to control the illumination of Io by the magnetosphere.

Other options are System III longitude of 200 - 245 or System III longitude 270 - 315, but if these are chosen, IO-ECLIPSED-HALF-2 should have the same System III longitude constraints

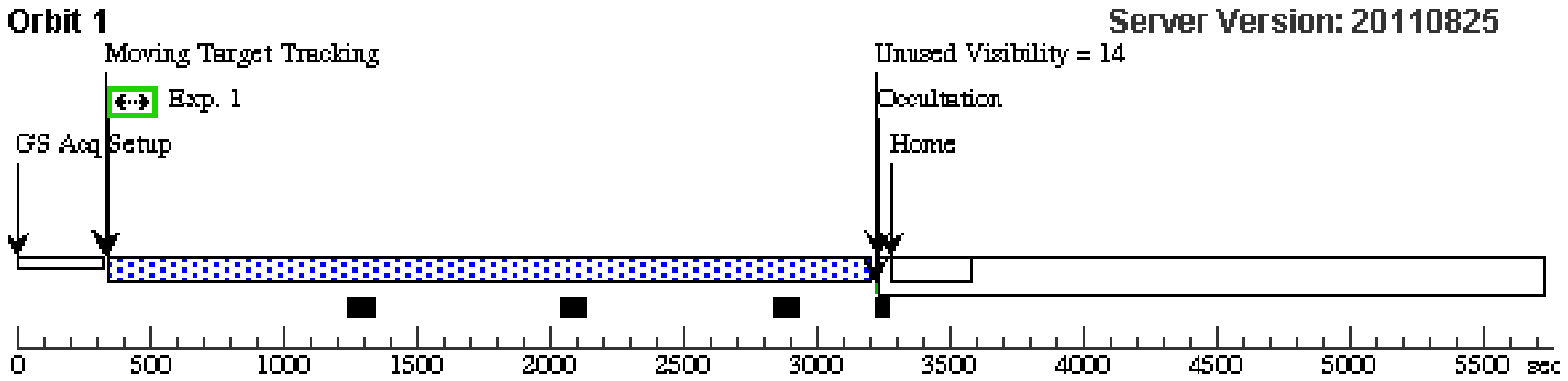
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(5) IO-EMERGED-2	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=800; FP-POS=1	GS ACQ SCENARIO BASE1B3		2740 Secs *[==>]*	*[1]*

Comments: ETC: COS78468 Used 3 strongest lines in this waveband (excluding Lyman alpha) from HST/FOS measurements by Clarke et al 1994, JGR 99., along with high airglow. Gives buffer time of 2/3 of 2919. We decrease this to 800s to allow for continuum or scatter.

The grating setting is chosen to detect the Io emission lines at 1256, 1304, 1356, 1389, and 1429 A. We do not vary FP-POS because we are looking for time variability and thus prefer to not change the instruments settings during the exposure. HOWEVER we should choose the best single FP-POS value after launch, to avoid (if possible) putting emission lines of interest on known problem areas of the detector.

Orbit Structure



Proposal 11539 - Visit 99 - COS-GTO: Io's Atmospheric Response to Eclipse

Visit

Proposal 11539, Visit 99, withdrawn Wed Dec 14 02:01:31 GMT 2011

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Comments: This is the old visit 3, retained here for the record. It has now been replaced with the new visits 3 and 4, which use blind acquisition. WE DO NOT INTEND TO IMPLEMENT THIS VISIT

We require this visit to be spread over two orbits, though it's hard to specify this in APT. The first orbit is used solely to acquire Europa. Once Europa has been successfully acquired, we wish to wait till the following HST orbit to observe Io, in order to get the longest possible unbroken observation of the critical time before and after eclipse reappearance. Hopefully the deflection from Europa to Io can be done in orbit 1 (or even during the Earth occultation??) so that we don't need to spend time during orbit 2 doing the offset. Io will be too close to Jupiter to observe (and possibly even behind Jupiter) during orbit 1.

We want 5 - 15 minutes of Exposure 4 (the science exposure) to be taken with Io in eclipse to establish a baseline, with the rest of the exposure in sunlight to observe the response of the atmosphere to eclipse re-emergence. There is thus a +/- 5 minute leeway in the timing of the eclipse reappearance relative to the HST orbit.

The observing window for this observation is in Fall 2009. If by that time targeting for COS observations has been improved to the point where ACQ/SEARCH acquisitions are not necessary, this might change our strategy, depending on how much the acquisition time can be shortened. If we can put Io in the COS aperture without doing a Europa offset acquisition that would be even better, and would allow us to observe two FUV Io eclipse reappearances, as originally planned.

Diagnostics

(Visit 99) Warning (Orbit Planner): VISIBILITY OVERRUN

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(2)	IO-ECLIPSED-HALF	STD=JUPITER	STD=IO		OLG OF IO FROM SUN BETWEEN 7.2 15.8, SEP OF IO-ECLIPSED-HALF JUPITER FROM EARTH GT 14.5"	EARTH

Comments: Target OLG window is determined based on:
-1.769 day orbital period of Io
-umbral eclipse begins at 9.4 +/-0.1 degrees OLG measured from Sun in Fall 2009
-3000s exposure time available in the second orbit.
-want to get 5-15 minutes with Io in eclipse, the remainder with Io emerged
Override default SEP between Io and Jupiter to allow observation in/near eclipse

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	EUROPA	STD=JUPITER	STD=EUROPA		SEP OF IO EUROPA FROM EARTH LT 118", SEP OF EUROPA JUPITER FROM EARTH GT 15"	EARTH

Comments: Use Europa since we can't acquire on Io when in eclipse (too dim)
NUV spectral acq target -- too bright for imaging acq. Must be within max offset of 120" from science target (Io).
Override default window SEP of Europa from JUPITER, to allow more available acq windows.
albedo at 2700Å is 0.45x visible albedo

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(3) EUROPA	COS/NUV, ACQ/SEARCH, PSA	G285M 2719 A	SCAN-SIZE=3			5 Secs *[==>]*	 ***[1]***
Comments: Spectroscopic ACQ ETC: COS77816 *use effective mV = 6.6 (based on albedo = 0.3 near 2700Å instead of 0.67 in visible; true mV = 5.7)* *Brightest and dimmest estimates (+/- 0.5 mags): COS77821, COS77823* *under 1s required for S/N = 40 in all cases, without exceeding count rate limit*									
2		(3) EUROPA	COS/NUV, ACQ/PEAKXD, PSA	G285M 2719 A				5 Secs *[==>]*	 ***[1]***
Comments: Spectroscopic ACQ ETC: COS94545 *use effective mV = 6.6 (based on albedo = 0.3 near 2700Å instead of 0.67 in visible; true mV = 5.7)* *Brightest and dimmest estimates (+/- 0.5 mags): COS94546, COS94547* *under 1s required for S/N = 40 in all cases, without exceeding count rate limit*									
3		(3) EUROPA	COS/NUV, ACQ/PEAKD, PSA	G285M 2719 A	STEP-SIZE=1.2; NUM-POS=7.0			5 Secs *[==>]*	 ***[1]***
4		(2) IO-ECLIPSED-HALF	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=1500			2892 Secs *[==>]*	 ***[2]***
Comments: ETC: COS78468 Used 3 strongest lines in this waveband (excluding Lyman alpha) from HST/FOS measurements by Clarke et al 1994, JGR 99., along with high airglow. *Gives buffer time of 2/3 of 2919. We decrease this to 1500s to allow for slight continuum or scatter.* *The grating setting is chosen to detect the Io emission lines at 1256, 1304, 1356, 1389, and 1429 A. We do not vary FP-POS because we are looking for time variability and thus prefer to not change the instruments settings during the exposure. HOWEVER we should choose the best single FP-POS value after launch, to avoid (if possible) putting emission lines of interest on known problem areas of the detector.* *This exposure is intended to occupy all of the second orbit of this visit, though there doesn't seem to be a way to tell this to APT, which tries to put it in the first orbit and then complains that it's too big to fit.*									

Orbit Structure