15147 - Extreme Doppler Shifting of Io's Neutral Jets

Cycle: 25, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
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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-LEADING (2) IO-OFFSET-LEADING DARK	COS/FUV COS/NUV	1	27-Feb-2018 15:00:42.0	yes
02	(3) IO-TRAILING (4) IO-OFFSET-TRAILING DARK	COS/FUV COS/NUV	1	27-Feb-2018 15:00:44.0	yes

2 Total Orbits Used

ABSTRACT

The dynamics and the extension of Jupiter's magnetosphere are determined by the massive internal plasma sources combined with the fast rotation. The vast majority of the plasma originates from the atmosphere of the moon Io, the most volcanically active body in our solar system. Here we propose to characterize the density and velocity of energetic neutral atoms escaping from Io's atmosphere. Exploiting the high resolution and

sensitivity of the COS G130M spectral mode, we will measure the Doppler velocities of atomic O, S and Cl streams, which are energized through charge exchange and dissociative recombination of molecular ions. Prior COS observations of Io revealed a large number of emission lines from several ion and neutral species with excellent S/N, obtained over a single HST orbit. Those spectra were obtained surrounding eclipse geometry, where Doppler shifts are minimized and were restricted to Io itself rather than the stream region. Here we will target the extended clouds with only two orbits total when the moon is at eastern and western elongation for maximum Doppler shifts. The observations will provide new constraints on the diffuse large-scale cloud structures in the Jovian system and significantly improve our understanding of the transport of mass and energy within the Io-torus interaction. The absolute brightness, in combination with plasma parameters from line ratios/collision strengths, will allow us to quantify the outflow of energetic neutral atoms from Io's main sulfur-oxygen atmosphere for the first time.

OBSERVING DESCRIPTION

Science goals necessitate a very restrictive time windows for these observations. One HST visit will be made for Io's elongation on each side of Jupiter. Precise centering is not required, so the observations utilize only acquire/search to reduce overhead. For each, spectra on and off of Io's disk will be compared. The COS aperture is to be pointed just off of Io's disk in the anti-jovian direction. This must occur during times when Io is just prior to its maximum elongation from Jupiter as seen from the Earth, where both Doppler shift and column density are maximized. Additionally, timing requires the sub-Io System III longitude of Jupiter to be in the 90-145 degree range, where the interaction between Io and the plasma torus is the greatest. Lastly, the orientation restriction is specified to align the long axis of the neutral jets (the Jovian magnetic equator) as close as possible to the COS cross-dispersion axis, thereby maximizing the effective spectral resolution. Visits while Io is visible from the southwestern US observatories (Large Binocular Telescope, Discovery Channel Telescope) are preferred, but not critical.

Visit

Proposal 15147, Leading (01), implementation Tue Feb 27 20:00:45 GMT 2018

Diagnostic Status: Error

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: ORIENT 218D TO 264 D

Comments: Ideal ORIENT angle is 241 or 61 degrees and the margin is here chosen for schedulability.

Aligning the long-axis of the neutral jets with COS the cross-dispersion Y axis will maximize the effective spectral resolution. This occurs at ORIENT 61 and 241 degrees and an orientation as close as possible to either value are requested. (Jovian North is 16 degrees east of Celestial North, so the leading side jet is aligned to a position angle of ~106. degrees. COS has V3 = Y - 45 = 61).

Diagnostics

(Disk Centered (01.002)) Error (Form): LIFETIME-POS is not a valid selection

(Disk Centered (01.002)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS.
The combination of attributes chosen is illegal.

(Disk Centered (01.002)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS=LP4.
The combination of attributes chosen is illegal.

(Neutral Jet (01.003)) Error (Form): LIFETIME-POS is not a valid selection

(Neutral Jet (01.003)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS.
The combination of attributes chosen is illegal.

(Neutral Jet (01.003)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS=LP4.
The combination of attributes chosen is illegal.

(Exposure 4 (Leading (01))) Error (Form): DEF is not a valid selection.

(Exposure 4 (Leading (01))) Error (Form): Illegal selection: DEF.

(Exposure 4 (Leading (01))) Error (Form): Target DARK is no longer a valid selection

(Exposure 4 (Leading (01))) Error (Form): This attribute cannot have this value due to other choices: Aperture=DEF.
This value is by default illegal.

(Exposure 4 (Leading (01))) Error (Form): This attribute cannot have this value due to other choices: Spectral_Element=DEF.
This value is by default illegal.

(Exposure 4 (Leading (01))) Error (Form): This attribute is not allowed to have this value: Calibration_Target = DARK
It is a Restricted option and can only be used in an engineering proposal.

(Leading (01)) Warning (Form): For the best data quality, it is strongly recommended that the maximum number of allowed FP-POS positions is used when observing at a given COS CENWAVE setting. See full description for details.

(Disk Centered (01.002)) Warning (Form): COS FUV PSA science exposures with extended targets have special calibration limitations. See "Errors and Warnings" for more details.

(Neutral Jet (01.003)) Warning (Form): COS FUV PSA science exposures with extended targets have special calibration limitations. See "Errors and Warnings" for more details.

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	IO-LEADING	STD=JUPITER	STD=IO		SEP OF IO-LEADING JUPITER FROM EARTH GT 30", SEP OF IO-LEADING CALLISTO FROM EARTH GT 10", SEP OF IO-LEADING EUROPA FROM EARTH GT 10", SEP OF IO-LEADING GANYMEDE FROM EARTH GT 10"	EARTH
Comments: Extended=YES						
(2)	IO-OFFSET-LEADING	STD=JUPITER	STD=IO	TYPE=POS_ANGLE,RAD=2.0,ANG=106.72,REF=NORTH	SEP OF IO-OFFSET-LEADING JUPITER FROM EARTH GT 30", SEP OF IO-OFFSET-LEADING CALLISTO FROM EARTH GT 10", SEP OF IO-OFFSET-LEADING EUROPA FROM EARTH GT 10", SEP OF IO-OFFSET-LEADING GANYMEDE FROM EARTH GT 10", OLG OF IO FROM EARTH BETWEEN 75.0 90.0, R_VEL IO EARTH LT -17.0, SEP OF IO-OFFSET-LEADING SUN FROM EARTH GT 130.0D, CML OF JUPITER FROM IO BETWEEN 90 145	EARTH

Comments: This offest is intended to point further east when Io is at its eastern (leading) elongation from Jupiter. Position angle is specied as Io's North Pole Position Angle (NPPA) + 90 degrees. At opposition, both Io and Jupiter's 's NPPA is 16.7 deg and its few degree change over the allowable observing windows is negligible. The offset radius places the limb of Io's disk 0.2" outside the 2.5" COS PSA at opposition.

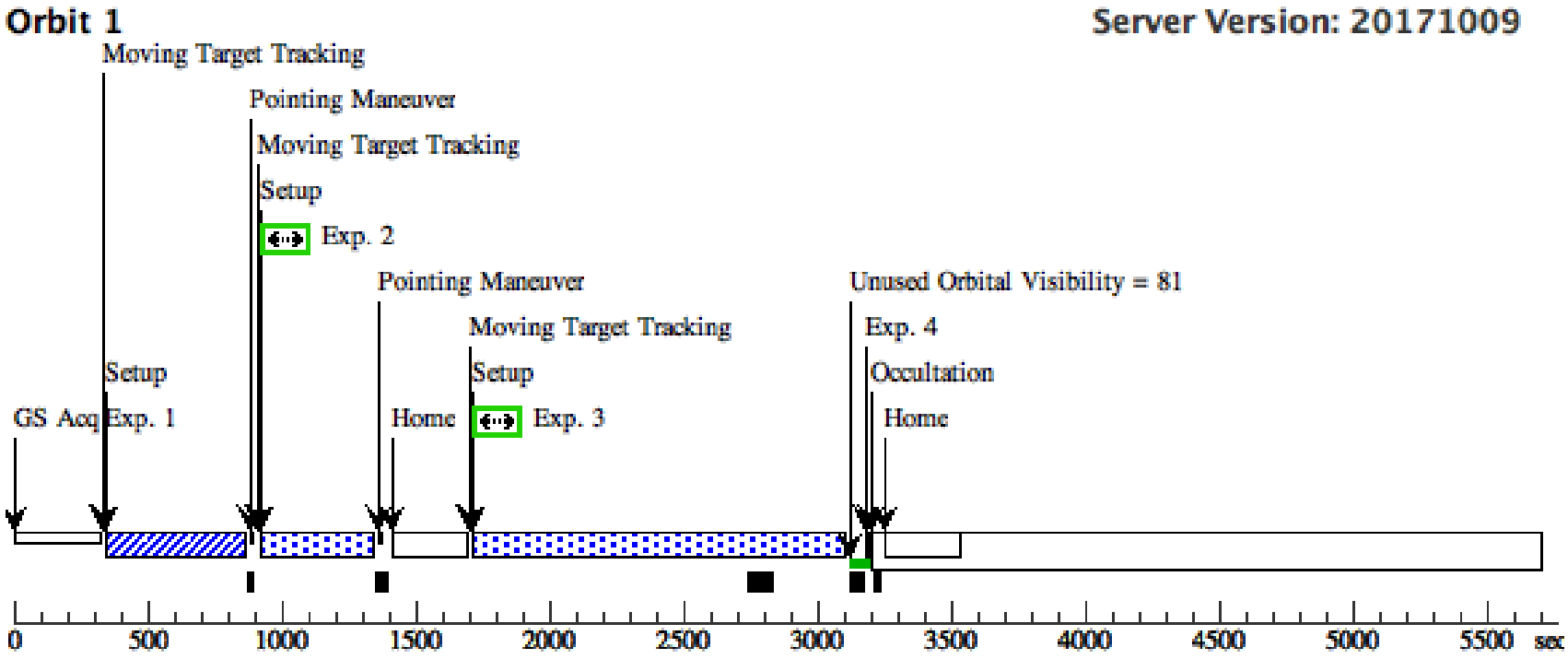
The most critical restriction on observing windows in Io's orbital longitude, since this maximizes both column density and Doppler shift. The oxygen lines to be observed are also present in terrestrial airglow. To minimize this terrestrial contribution, we choose to observe near opposition to maximize time in Earth's shadow, and at high Doppler blueshift to best seperate the oxygen line spread functions of each component. Lastly, Io must be near the torus' centrifugal equator to maximize the density driving emissions. Therefore, the sub-Io Jupiter System III longitude should be between 90 and 145 degrees.
Extended=YES

Acquisition Uncertainty: 0.1 Arcsec

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acq/Search (COS.sa.1010061)	(1) IO-LEADING	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=3; CENTER=FLUX-WT-FLR	GS ACQ SCENARIO BASE1B3		1 Secs (1 Secs) [==>]	[1]
	Comments: Io's surface brightness uploaded to the COS ETC. We calculate this using the Earth-Sun-Io geometry, the disk-averaged geometric albedos from Feaga et al. (2004 FUV), Clarke et al. (1994 JGR Fig 7b) and Tsang et al. (2013) in the NUV, and Nelson et al. (1996 Fig 1b, Visibile), and the NRL solar irradiance http://lasp.colorado.edu/lisird/nrlssi/ near solar maximium. COS.sa.1010061								
2	Disk Centered (COS.sp.1010060)	(1) IO-LEADING	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=1000; SEGMENT=BOTH; LIFETIME-POS=LP4			250 Secs (249 Secs) [==>249.0 Secs]	[1]
	*Comments: Io spectrum in the ETC is the same as previous. COS.sp.1010060 gives buffer time =2/3*8,614 s. We choose 1000s to allow plenty of margin for bright emissions near the ansae of the plasma torus.*								
3	Neutral Jet (COS.sp.1010060)	(2) IO-OFFSET-LEADING	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=1000; FP-POS=4; SEGMENT=BOTH; LIFETIME-POS=LP4	GS ACQ SCENARIO BASE1B3		1341 Secs (1341 Secs) [==>]	[1]
	*Comments: Io spectrum in the ETC is the same as previous. COS.sp.1010060 gives buffer time =2/3*8,614 s. We choose 1000s to allow plenty of margin for bright emissions near the ansae of the plasma torus.*								
4		DARK	COS/NUV, TIME-TAG, DEF	DEF	BUFFER-TIME=80			4 Secs (4 Secs) [==>]	[1]

Orbit Structure



Visit

Proposal 15147, Trailing (02), implementation Tue Feb 27 20:00:45 GMT 2018

Diagnostic Status: Error

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: ORIENT 35D TO 89 D

Comments: Ideal ORIENT angle is 62 or 242 and the margin is here chosen for schedulability.

Aligning the long-axis of the neutral jets with COS the cross-dispersion Y axis will maximize the effective spectral resolution. This occurs at ORIENT 62 and 242 degrees, so orientations as close as possible to either value are requested. (Jovian North is 16 deg east of Celestial North, so the trailing side jet is aligned to a position angle of ~287. degrees. COS has V3 = Y - 45 = 242).

Diagnostics

(Disk Centered (02.002)) Error (Form): LIFETIME-POS is not a valid selection

(Disk Centered (02.002)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS.
The combination of attributes chosen is illegal.

(Disk Centered (02.002)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS=LP4.
The combination of attributes chosen is illegal.

(Neutral Jet (02.003)) Error (Form): LIFETIME-POS is not a valid selection

(Neutral Jet (02.003)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS.
The combination of attributes chosen is illegal.

(Neutral Jet (02.003)) Error (Form): This attribute cannot have this value due to other choices: Optional_Parameter=LIFETIME-POS=LP4.
The combination of attributes chosen is illegal.

(Exposure 4 (Trailing (02))) Error (Form): DEF is not a valid selection.

(Exposure 4 (Trailing (02))) Error (Form): Illegal selection: DEF.

(Exposure 4 (Trailing (02))) Error (Form): Target DARK is no longer a valid selection

(Exposure 4 (Trailing (02))) Error (Form): This attribute cannot have this value due to other choices: Aperture=DEF.
This value is by default illegal.

(Exposure 4 (Trailing (02))) Error (Form): This attribute cannot have this value due to other choices: Spectral_Element=DEF.
This value is by default illegal.

(Exposure 4 (Trailing (02))) Error (Form): This attribute is not allowed to have this value: Calibration_Target = DARK
It is a Restricted option and can only be used in an engineering proposal.

(Trailing (02)) Warning (Form): For the best data quality, it is strongly recommended that the maximum number of allowed FP-POS positions is used when observing at a given COS CENWAVE setting. See full description for details.

(Disk Centered (02.002)) Warning (Form): COS FUV PSA science exposures with extended targets have special calibration limitations. See "Errors and Warnings" for more details.

(Neutral Jet (02.003)) Warning (Form): COS FUV PSA science exposures with extended targets have special calibration limitations. See "Errors and Warnings" for more details.

Solar System Targets

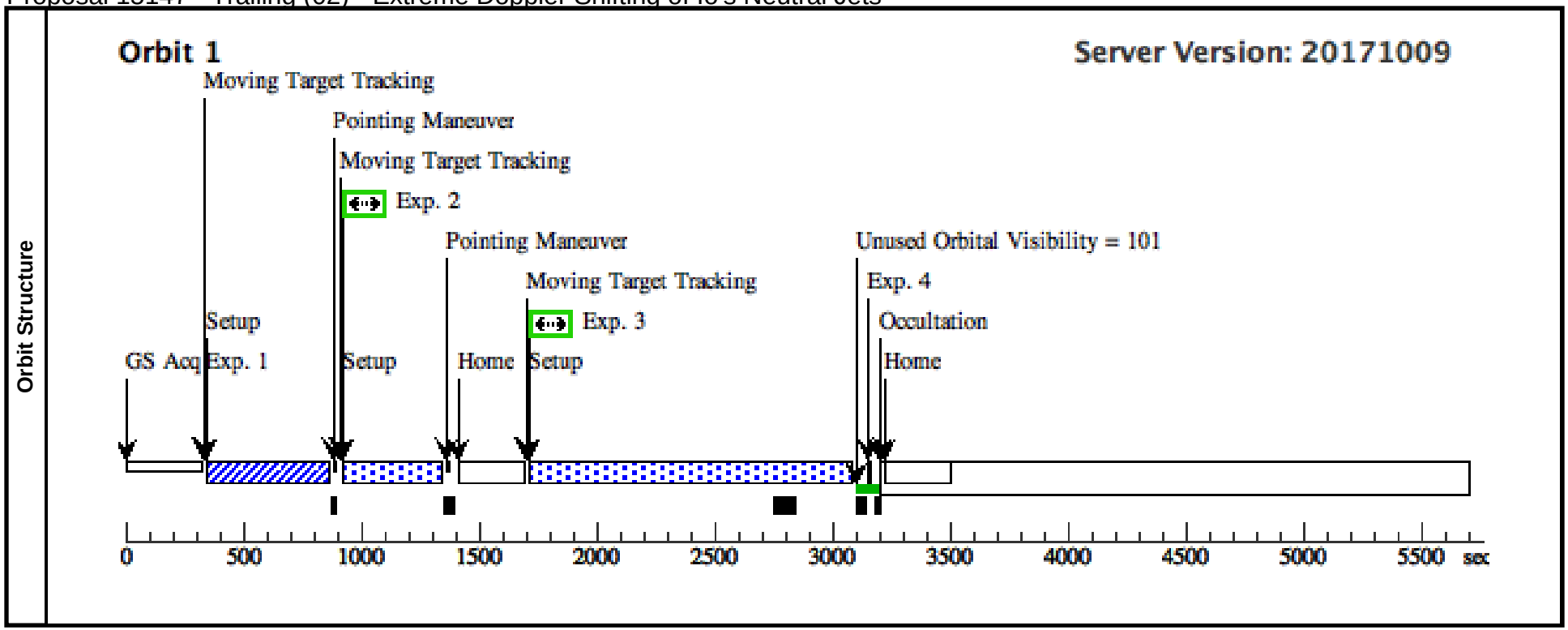
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	IO-TRAILING	STD=JUPITER	STD=IO		SEP OF IO-TRAILING JUPITER FROM EARTH GT 30", SEP OF IO-TRAILING CALLISTO FROM EARTH GT 10", SEP OF IO-TRAILING EUROPA FROM EARTH GT 10", SEP OF IO-TRAILING GANYMEDE FROM EARTH GT 10"	EARTH
Comments: Extended=YES						
(4)	IO-OFFSET-TRAILING	STD=JUPITER	STD=IO	TYPE=POS_ANGLE,RAD=2.0,ANG=286.72,REF=NORTH	SEP OF IO-OFFSET-TRAILING JUPITER FROM EARTH GT 30", SEP OF IO-OFFSET-TRAILING CALLISTO FROM EARTH GT 10", SEP OF IO-OFFSET-TRAILING EUROPA FROM EARTH GT 10", SEP OF IO-OFFSET-TRAILING GANYMEDE FROM EARTH GT 10", OLG OF IO FROM EARTH BETWEEN 255.0 270.0, R_VEL IO EARTH GT 17.0, SEP OF IO-OFFSET-TRAILING SUN FROM EARTH GT 130.0D, CML OF JUPITER FROM IO BETWEEN 90 145	EARTH

Comments: This offest is intended to point further west when Io is at its western elongation from Jupiter. Position angle is specied as Io's North Pole Position Angle (NPPA) + 270 degrees. At opposition, both Io and Jupiter's 's NPPA is 16.7 deg and its few degree change over the allowable observing windows is negligible. The offset radius places the limb of Io's disk 0.2" outside the 2.5" COS PSA at opposition.

The most critical restriction on observing windows in Io's orbital longitude, since this maximizes both column density and relative velocity needed for primary science goals. The oxygen lines to be observed are also present in terrestrial airglow. To minimize this terrestrial contribution, we choose to observe near opposition to maximize time in Earth's shadow, and at high Doppler redshift to best seperate the oxygen line spread functions of each component. Lastly, Io must be near the torus' centrifugal equator to maximize the density driving emissions. Therefore, the sub-Io Jupiter System III longitude should be between 90 and 145 degrees. Extended=YES

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acq/Search (COS.sa.1010061)	(3) IO-TRAILING	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=3; CENTER=FLUX-WT-FLR	GS ACQ SCENARIO BASE1B3		1 Secs (1 Secs)	
								[==>]	***[1]***
Comments: Io's surface brightness uploaded to the COS ETC. We calculate this using the Earth-Sun-Io geometry, the disk-averaged geometric albedos from Feaga et al. (2004 FUV), Clarke et al. (1994 JGR Fig 7b) and Tsang et al. (2013) in the NUV, and Nelson et al. (1996 Fig 1b, Visibile), and the NRL solar irradiance http://lasp.colorado.edu/lisird/nrlssi/ near solar maximium. COS.sa.1010061									
2	Disk Centered (COS.sp.1010059)	(3) IO-TRAILING	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=1000; FP-POS=3; SEGMENT=BOTH; LIFETIME-POS=LP4			250 Secs (250 Secs)	
								[==>]	***[1]***
*Comments: Io spectrum in the ETC is the same as previous. COS.sp.1010059 gives buffer time =2/3*8,614 s. We choose 1000s to allow plenty of margin for bright emissions near the ansae of the plasma torus.*									
3	Neutral Jet (COS.sp.1010059)	(4) IO-OFFSET-TRAILING	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=1000; FP-POS=4; SEGMENT=BOTH; LIFETIME-POS=LP4	GS ACQ SCENARIO BASE1B3		1320 Secs (1320 Secs)	
								[==>]	***[1]***
*Comments: Io spectrum in the ETC is the same as previous. COS.sp.1010059 gives buffer time =2/3*8,614 s. We choose 1000s to allow plenty of margin for bright emissions near the ansae of the plasma torus.*									
4		DARK	COS/NUV, TIME-TAG, DEF	DEF	BUFFER-TIME=80			4 Secs (4 Secs)	
								[==>]	***[1]***


Orbit Structure
Orbit 1
Server Version: 20171009
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Exp. 2
Pointing Maneuver
Moving Target Tracking
Exp. 3
Unused Orbital Visibility = 101
Exp. 4
Occultation
Setup
GS Acq
Exp. 1
Setup
Home
Setup
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec