14650 - A simple definitive test for chloride salts on Europa

Cycle: 24, Proposal Category: GO

(Availability Mode: AVAILABLE)

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?*
12	(1) EUROPA-45 CCDFLAT WAVE	STIS/CCD	1	09-Nov-2016 11:33:45.0	yes
13	(2) EUROPA-135 CCDFLAT WAVE	STIS/CCD	1	09-Nov-2016 11:33:51.0	yes
14	(3) EUROPA-225 CCDFLAT WAVE	STIS/CCD	1	09-Nov-2016 11:33:57.0	yes
15	(4) EUROPA-315 CCDFLAT WAVE	STIS/CCD	1	09-Nov-2016 11:34:03.0	yes

4 Total Orbits Used

ABSTRACT

Europa is a prime location for exploring our concepts of habitability throughout the solar system. As importantly, Europa is a case study for how liquid water drives the geochemistry and geophysics in a world very different from our own. One of the keys to understanding the liquid water's effect on habitability, geochemistry, and even on geophysics is understanding the chemistry of the internal ocean. Evaporites on the surface of Europa provide a window into this ocean chemistry.

Recent observations have overturned 15 years worth of assumptions about the chemistry of Europa's ocean and have suggested that chloride salts -- rather than sulfate salts -- could be the most abundant constituent in the ocean and in the surface evaporites. The possibility of chloride salts has major implications for geophysics and habitability, but, because chloride salts are basically featureless, definitive spectral evidence was thought impossible.

New laboratory data now shows, however, that electron irradiation with Europa-like fluxes imparts distinct spectral absorption features on chloride salts. These spectral features, in specific bands between 430 and 830 nm, are uniquely accessible to high spatial resolution HST spectroscopy. We propose a very simple program to obtain four separate high spatial resolution STIS slit scans across the disk of Europa to construct a global spectral map which will detect and map these surface salts. These observations can definitively identify chloride salts on Europa and fundamentally change our understanding of this world. Rarely can such a simple and short program with HST have the possibility of obtaining such conclusive and transformative results.

OBSERVING DESCRIPTION

We consider four factors in designing our observation sequence: spectral coverage, signal-to-noise, spatial resolution, and observing efficiency. STIS low resolution CCD spectroscopy perfectly covers the wavelengths of the NaCl and KCl color centers. The G430L mode will cover 460 nm NaCl and most of the broad 550 nm KCl color centers, while the G750L mode will cover the remainder of the 550 nm KCl (with significant overlap to stitch the two together) as well as the 647 and 830 nm color centers due to KCl and the strong 723 NaCl color center. Even at low resolution, there will be ~30 resolution elements across these ~50 nm wide spectral features. We estimate that if the spectrum is similar to that of the ocean brine, but diluted with pure ice by a factor of 50% as suggested by Fischer et al., we would require a S/N of 200 across the band to make a 10% detection of the ~5% absorption feature, or a S/N of approximately 25 per pixel across these bands. In the short wavelength band, this S/N is achieved in a 2 second (!) exposure (with a 140 second exposure required for saturation). In the long wavelength band, the required exposure time is 1.6 seconds (with 48

seconds until saturation). Clearly, these observations will be dominated by overhead rather than integration time. We discuss how to efficiently scan the spatial slit across Europa after first determining the number of visits required, which is set by the spatial resolution required.

The spatial resolutions of Keck near-infrared AO and HST optical imaging are well matched. Our goal is to obtain visible spectral maps with spatial resolution comparable to our existing infrared data. The highest spatial resolution is achieved only at the sub-observer point (the equator at the central longitude of the observation). All other locations at the disk will be foreshortened in each observation. A four visit sequence is the optimal trade-off between full disk spatial resolution and observing efficiency. With four visits sequenced ~90 degrees of longitude apart on the satellite, the worst spatial resolution achieved on the equator will be 45 degrees off of each sub-observer point and will be degraded by 40% compared to the sub-observer resolution. Such a degradation appears acceptable compared to the sizes of the features seen in Figure 1. (A sequence of only 3 visits would lead to resolution degradations of 100%, comparable to the size of some of the features we are attempting to detect).

Within each visit, we seek an observational sequence that efficiently observes both spectral settings while scanning the slit across the surface of Europa with steps small enough to maximize spatial resolution. The observing window for these ecliptic observations is 54 minutes. After a six minute guide star acquisition, we will require a 6 minute STIS peak up, leaving 42 minutes for observation. Our ideal sequence would then be 26 separate spatial positions with 0.025 arcseconds spacing across the ~0.65 arcsecond central region of Europa which contains the 90 degree sub-observer quadrant (we need not scan to the limb as those regions are better covered at other phases). Each of the two spectral setups requires a 4 minute overhead (plus subsequent readout), so, if we complete one full spectral sequence before switching, we have 40 minutes total remaining for exposure, readout, and dither of 52 spectra. If we assume 20 seconds for each dither and obtain a readout of 7 seconds by using a 256 column subaperture, we can expose each spectrum for 20 seconds. We will obtain ~3 times the required S/N, while staying well below saturation. In addition, the use of subapertures should guarantee that we do not need to pause for STIS buffer dump.

We are mapping the entire surface of Europa. The four visits should occur at Europa phases which are ~90 degrees apart. To stay as far from Jupiter as possible, the visits should be centered at phases of 45, 135, 225, and 315 degrees (with an acceptable range of ~5 degrees). The observations need not occur within a single Europa orbit. The other Galilean satellites should each be greater than 5 arcseconds away during each observation.

Visit

Proposal 14650, Europa-45 (12), implementation Wed Nov 09 16:34:05 GMT 2016

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=STIS-PERP-TO-SLIT	Coordinate Frame=POS-TARG		(3), (4)
	Purpose=MOSAIC	Pattern Orientation=0.0		
	Number Of Points=15	Angle Between Sides=		
	Point Spacing=0.06	Center Pattern=true		
	Line Spacing=			

Solar System Targets

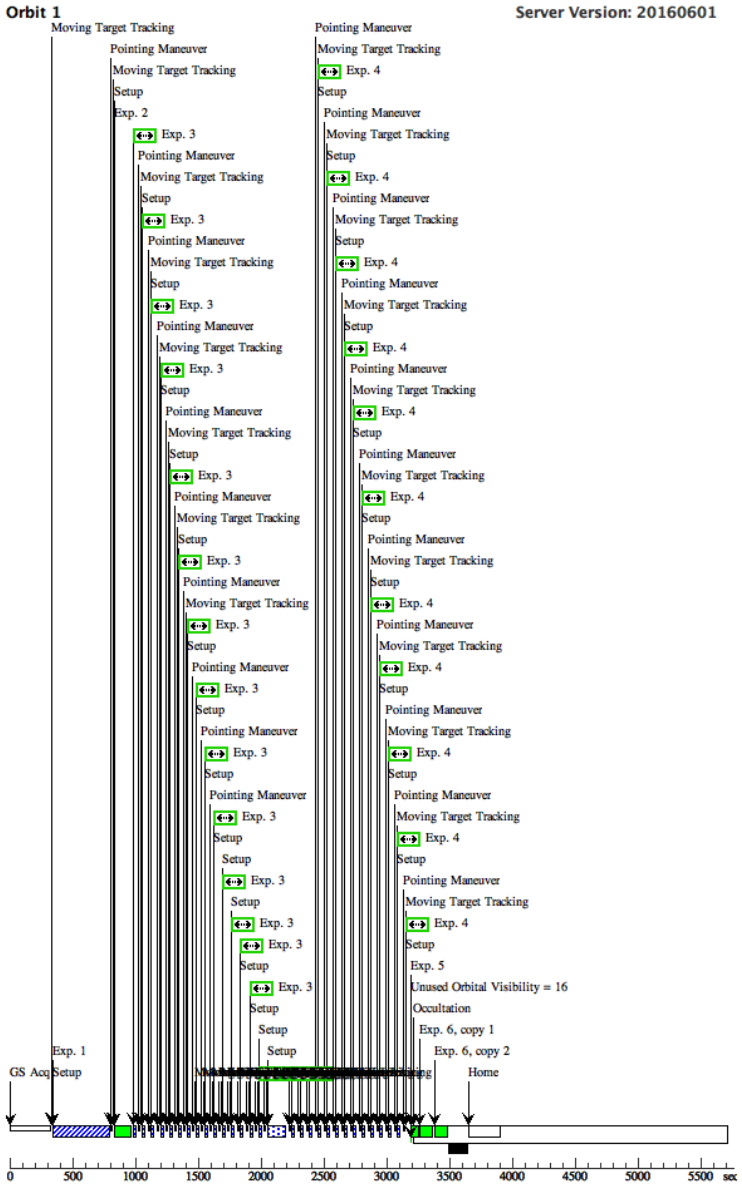
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	EUROPA-45	STD=JUPITER	STD=EUROPA		SEP OF EUROPA-45 JUPITER FROM EARTH GT 30", SEP OF EUROPA-45 CALLISTO FROM EARTH GT 10", SEP OF EUROPA-45 IO FROM EARTH GT 10", SEP OF EUROPA-45 GANYMEDE FROM EARTH GT 10", CML OF EUROPA-45 FROM EARTH BETWEEN 40 50	EARTH

Comments: 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 (823551)	(1) EUROPA-45	STIS/CCD, ACQ, F25ND3	MIRROR	ACQTYPE=DIFFUSE; CHECKBOX=21; DIFFUSE-CENTER=GEOMETRIC-CENTER			5 Secs (5 Secs) *[==>]*	***[1]***
2	Wavecal for 430L	WAVE	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A				*[==>]*	***[1]***
3	Europa-45 G 430L Scan (823952)	(1) EUROPA-45	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A	CR-SPLIT=NO; SIZEAXIS2=80; WAVECAL=NO		Pattern 3, Exps 3-3 in Europa-45 (12) (3)	10 Secs (150 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
4	Europa-45 G 750L Scan (823953)	(1) EUROPA-45	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A	CR-SPLIT=NO; SIZEAXIS2=80		Sequence 4-5 Non-Int in Europa-45 (12) Pattern 3, Exps 4-4 in Sequence 4-5 Non-Int in Europa-45 (12) (3)	9 Secs (135 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
5	Wavecal for 750L	WAVE	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A		NEW ALIGNMENT	Sequence 4-5 Non-Int in Europa-45 (12)	*[==>]*	***[1]***
6	Fringe Flat	CCDFLAT	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A				*[==>(Copy 1)]* *[==>(Copy 2)]*	***[1]***

Orbit Structure



Visit

Proposal 14650, Europa-135 (13), implementation Wed Nov 09 16:34:05 GMT 2016

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=STIS-PERP-TO-SLIT	Coordinate Frame=POS-TARG		(3), (4)
	Purpose=MOSAIC	Pattern Orientation=0.0		
	Number Of Points=15	Angle Between Sides=		
	Point Spacing=0.06	Center Pattern=true		
	Line Spacing=			

Solar System Targets

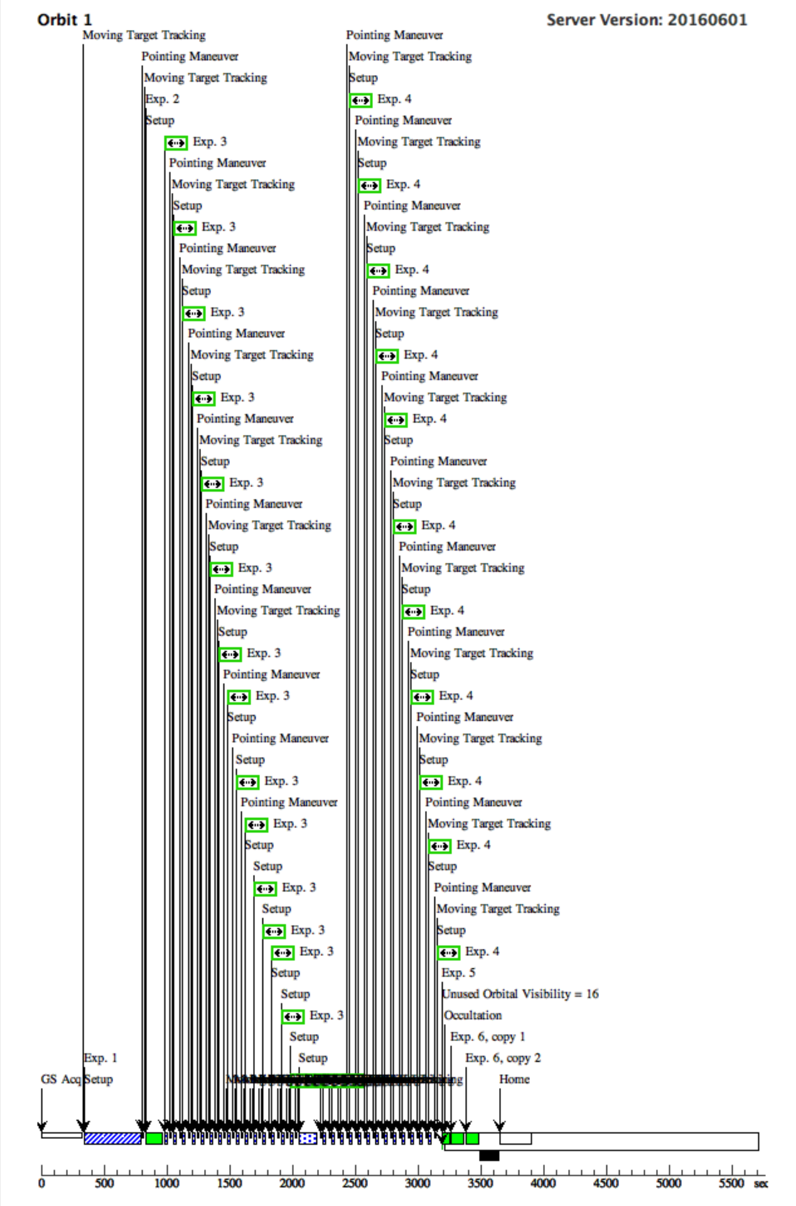
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(2)	EUROPA-135	STD=JUPITER	STD=EUROPA		SEP OF EUROPA-135 JUPITER FROM EARTH GT 30", SEP OF EUROPA-135 CALLISTO FROM EARTH GT 10", SEP OF EUROPA-135 IO FROM EARTH GT 10", SEP OF EUROPA-135 GANYMEDE FROM EARTH GT 10", CML OF EUROPA-135 FROM EARTH BETWEEN 130 140	EARTH

Comments: 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 (823551)	(2) EUROPA-135	STIS/CCD, ACQ, F25ND3	MIRROR	ACQTYPE=DIFFUSE; CHECKBOX=21; DIFFUSE-CENTER=GEOMETRIC-CENTER			5 Secs (5 Secs) *[==>]*	***[1]***
2	Wavecal for 430L	WAVE	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A				*[==>]*	***[1]***
3	Europa-135 G430L Scan (823952)	(2) EUROPA-135	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A	CR-SPLIT=NO; SIZEAXIS2=80; WAVECAL=NO		Pattern 3, Exps 3-3 in Europa-135 (13) (3)	10 Secs (150 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
4	Europa-135 G750L Scan (823953)	(2) EUROPA-135	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A	CR-SPLIT=NO; SIZEAXIS2=80		Sequence 4-5 Non-Int in Europa-135 (13) Pattern 3, Exps 4-4 in Sequence 4-5 Non-Int in Europa-135 (13) (3)	9 Secs (135 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
5	Wavecal for 750L	WAVE	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A		NEW ALIGNMENT	Sequence 4-5 Non-Int in Europa-135 (13)	*[==>]*	***[1]***
6	Fringe Flat	CCDFLAT	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A				*[==>(Copy 1)]* *[==>(Copy 2)]*	***[1]***

Orbit Structure



Visit

Proposal 14650, Europa-225 (14), implementation Wed Nov 09 16:34:05 GMT 2016

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=STIS-PERP-TO-SLIT	Coordinate Frame=POS-TARG		(3), (4)
	Purpose=MOSAIC	Pattern Orientation=0.0		
	Number Of Points=15	Angle Between Sides=		
	Point Spacing=0.06	Center Pattern=true		
	Line Spacing=			

Solar System Targets

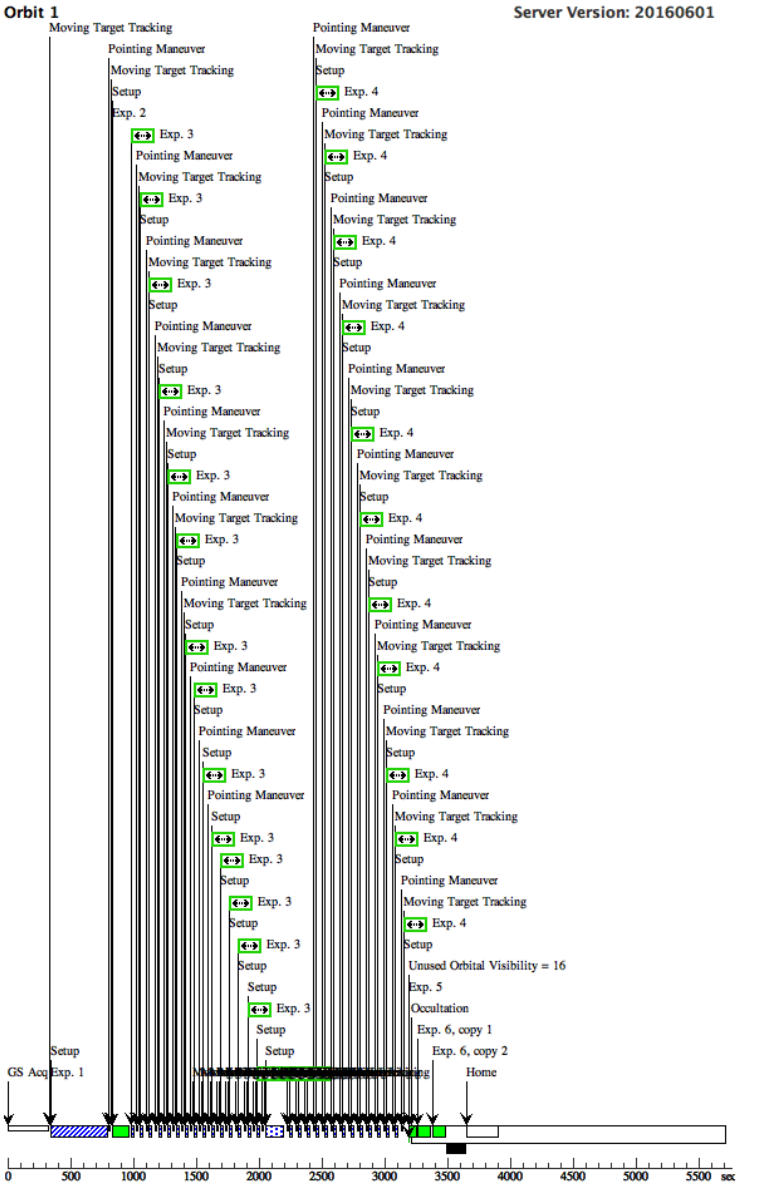
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	EUROPA-225	STD=JUPITER	STD=EUROPA		SEP OF EUROPA-225 JUPITER FROM EARTH GT 30", SEP OF EUROPA-225 CALLISTO FROM EARTH GT 10", SEP OF EUROPA-225 IO FROM EARTH GT 10", SEP OF EUROPA-225 GANYMEDE FROM EARTH GT 10", CML OF EUROPA-225 FROM EARTH BETWEEN 220 230	EARTH

Comments: 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 (823551)	(3) EUROPA-225	STIS/CCD, ACQ, F25ND3	MIRROR	ACQTYPE=DIFFUSE; CHECKBOX=21; DIFFUSE-CENTER=GEOMETRIC-CENTER			5 Secs (5 Secs) *[==>]*	***[1]***
2	Wavecal for 430L	WAVE	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A				*[==>]*	***[1]***
3	Europa-225 G430L Scan (823952)	(3) EUROPA-225	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A	CR-SPLIT=NO; SIZEAXIS2=80; WAVECAL=NO		Pattern 3, Exps 3-3 in Europa-225 (14) (3)	10 Secs (150 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
4	Europa-225 G750L Scan (823953)	(3) EUROPA-225	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A	CR-SPLIT=NO; SIZEAXIS2=80		Sequence 4-5 Non-Int in Europa-225 (14) Pattern 3, Exps 4-4 in Sequence 4-5 Non-Int in Europa-225 (14) (3)	9 Secs (135 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
5	Wavecal for 750L	WAVE	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A		NEW ALIGNMENT	Sequence 4-5 Non-Int in Europa-225 (14)	*[==>]*	***[1]***
6	Fringe Flat	CCDFLAT	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A				*[==>(Copy 1)]* *[==>(Copy 2)]*	***[1]***

Orbit Structure



Visit

Proposal 14650, Europa-315 (15), implementation Wed Nov 09 16:34:05 GMT 2016

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=STIS-PERP-TO-SLIT	Coordinate Frame=POS-TARG		(3), (4)
	Purpose=MOSAIC	Pattern Orientation=0.0		
	Number Of Points=15	Angle Between Sides=		
	Point Spacing=0.06	Center Pattern=true		
	Line Spacing=			

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(4)	EUROPA-315	STD=JUPITER	STD=EUROPA		SEP OF EUROPA-315 JUPITER FROM EARTH GT 30", SEP OF EUROPA-315 CALLISTO FROM EARTH GT 10", SEP OF EUROPA-315 IO FROM EARTH GT 10", SEP OF EUROPA-315 GANYMEDE FROM EARTH GT 10", CML OF EUROPA-315 FROM EARTH BETWEEN 310 320	EARTH

Comments: 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 (823551)	(4) EUROPA-315	STIS/CCD, ACQ, F25ND3	MIRROR	ACQTYPE=DIFFUSE; CHECKBOX=21; DIFFUSE-CENTER=GEOMETRIC-CENTER			5 Secs (5 Secs) *[==>]*	***[1]***
2	Wavecal for 430L	WAVE	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A				*[==>]*	***[1]***
3	Europa-315 G430L Scan (823952)	(4) EUROPA-315	STIS/CCD, ACCUM, 52X0.1	G430L 4300 A	CR-SPLIT=NO; SIZEAXIS2=80; WAVECAL=NO		Pattern 3, Exps 3-3 in Europa-315 (15) (3)	10 Secs (150 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
4	Europa-315 G750L Scan (823953)	(4) EUROPA-315	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A	CR-SPLIT=NO; SIZEAXIS2=80		Sequence 4-5 Non-Int in Europa-315 (15) Pattern 3, Exps 4-4 in Sequence 4-5 Non-Int in Europa-315 (15) (3)	9 Secs (135 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]* *[==>(Pattern 10)]* *[==>(Pattern 11)]* *[==>(Pattern 12)]* *[==>(Pattern 13)]* *[==>(Pattern 14)]* *[==>(Pattern 15)]*	***[1]***
5	Wavecal for 750L	WAVE	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A		NEW ALIGNMENT	Sequence 4-5 Non-Int in Europa-315 (15)	*[==>]*	***[1]***
6	Fringe Flat	CCDFLAT	STIS/CCD, ACCUM, 52X0.1	G750L 7751 A				*[==>(Copy 1)]* *[==>(Copy 2)]*	***[1]***

Orbit Structure