16254 - Stellar X-ray Cycles: the Shape of Things to Come

Cycle: 28, Proposal Category: GO

(Availability Mode: AVAILABLE)

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?*
10	(1) HD128620 (2) HD128621 WAVE	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	03-Feb-2021 13:00:14.0	yes
11	(3) HD61421 WAVE	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	2	03-Feb-2021 13:00:16.0	yes

5 Total Orbits Used

ABSTRACT

Somewhat erratic, unpredictable long-term starspot cycles of late-type stars are relevant for understanding the Sun's analogous high-energy modulations, in turn crucial to Earth-impacting "Space Weather" (SW). Similarly, stellar SW counterparts can have eqivalent, or more severe, adverse effects on their exoplanets. The solar decadal oscillations are symptomatic of a deep-seated magnetic pump -- the Dynamo -- whose internal workings remain elusive. Key question: is Sun's 11-year cycle normal, or instead a transition state? A 3-year continuation of previous long-term Chandra/HST programs will be carried out for Alpha Cen AB (G2V+K1V) and Procyon (F5IV), nearby bright stars that bracket the Sun in their fundamental stellar properties.

HST part of the program will measure FUV subcoronal (T~100,000 K) emission lines, like Si IV 140 nm and C IV 155 nm, as well as the important NUV chromospheric (T~10,000 K) emission doublet of Mg II at 280 nm, in all three stars, with one visit of STIS echelle spectroscopy per system each year. Non-standard wavecals provide better wavelength calibrations, so that subtle Doppler shifts of the high-excitation emissions can be assessed. Dynamical information also is encoded in distortions of the line shapes, captured using combinations of FUV medium- and high-resolution echelle settings.

OBSERVING DESCRIPTION

Impact of Reduced Gyro Mode

Main impact of RGM would fall on target Alpha Cen A+B (see below), for which CVZ orbits are specified, together with an orientation constraint for one of the ND-filtered long-slit exposures, to avoid having both stars (currently only ~6" apart) fall on the slit at the same time. If RGM becomes necessary in Cycle 28, before the the Alp Cen observation is scheduled, then the observing program would be modified as follows: (1) the two NUV echelle exposures would be eliminated (one of which uses the problematic long-slit); (2) the FUV exposures of both stars would be done with high-sensitivity E140M-1425 (in 3-gyro Phase II, a pair of E140H's are used for Alp Cen B, which has narrower emission lines); and (3) the exposure times would be reduced to allow the 2-orbit pointing to be carried out in non-CVZ time, to increase scheduling opportunities. The loss in science would be minor, because the FUV spectral region is the highest priority in terms of its potential information content.

The second target, Procyon, another bright star, would be minimally affected by RGM, because there are no explicit constraints on the observation sequence, it can be carried out anytime during Cycle 28 when the target is available, and the pointing is only 2 orbits, minimizing the possibility of re-acquisition failures. However, if acquisition times are increased, then one or more of the exposures would have to be shortened. This can be done with minimal loss of science.

Phase II Observing Description (for normal 3-gyro operations)

The high-declination Alpha Cen system falls in the HST Continuous Viewing Zone numerous times during the year, allowing the two stars to be captured in a single visit of just two orbits. One such visit is planned for Cycle 28, compatible with the semiannual pointings by Chandra. There is no

need to strictly coordinate the FUV and X-ray pointings, because the FUV Fe XII 124 nm coronal forbidden line can tie the STIS observation into the X-ray timeline.

In the single HST/STIS visit, the binary companions are observed sequentially, beginning with Alp Cen A, brighter of the two. The target is acquired with the CCD and F25ND5, followed by an exposure with the E140M-1425 medium-res echelle through the photometric slot (0.2x0.2), which delivers R=40,000 and good sensitivity (peak S/N=40 per resol at the tops of the important Si IV 140 nm and C IV 155 nm resonance doublets). A peak-up is not needed because the CCD ACQ is accurate enough for centering in the photometric slot. The exposure depth is sufficient to capture the key Fe XII 124 nm coronal forbidden line, which as mentioned earlier is used to tie the STIS FUV measurements into the X-ray time series. The combination of resolution, spectral coverage, and sensitivity of E140M for A has proven successful in previous incarnations of this program. Following the E140M exposure, a peak-up is performed with the 31x0.05NDC slit in dispersed visible light with the CCD and G430M; then an E230H-2713 exposure is taken through that (long) slit. This setting captures the key chromospheric Mg II 280 nm resonance doublet.

After the Alp Cen A exposures, a ~5" offset manuever to B is performed, followed by a CCD ACQ through F25ND5. The time-dependent separation of the binary companions is accurately known (to ~0.1"), based on orbital reconstructions of ten years of positional measurements by Chandra. Similarly, the coordinates and (an effective) proper motion of Alp Cen A were updated for Cycle 26 (and should be good for several Cycles more based on combining the orbital and proper motion solutions derived from the Chandra positions to trace out A's trajectory across the sky.

After the CCD-ACQ of B, an E140M-1425 exposure is taken through the photometric aperture. This is a small change from the previous Cycles, when a pair of E140H's was taken, but is in anticipation of RGM (see above). The E140M setting also has the advantage of broader wavelength coverage, especially C III 117 nm, missed with the E140H sequence. By using the 0.2x0.2 photometric aperture, sensitivity is maximized without significantly sacrificing resolution, as well as minimizing telescope "breathing" effects. Following the E140M exposure, an E230H-2713 is taken, again to cover the important Mg II region. The 0.2x0.09 spectroscopic aperture can be used, because the previously measured Global Count Rate with this setting is below the bright limit, and B is only minimally variable in the continuum light that dominates that setting (the Mg II lines can be more variable, but do not contribute signifcantly to the total flux in that region; and do not approach the local bright limit). A peak-up ensures maximum throughput. The whole FUV+NUV sequence for both stars requires two CVZ orbits.

Also, because a tall slit is used for A, an ORIENT constraint is specified to avoid having both targets fall on the slit simultaneously, and consequently corrupt the echellegram with overlapping spectra (and possibly also violate the global limits). The constraint is not severe, however, because the NDC slit is only 0.05" wide and the separation of the stars will be ~6" in 2020. A +/- 10 degree avoidance zone (+/- 1" pivot from B) should be

sufficient to exclude B and any possible scattered light. The ORIENT avoidance zones for 2021 are listed in the Visit-level specifications. There are numerous CVZ windows throughout the year that satisfy the ORIENT constraints.

The proposed STIS observations of Procyon are similar. There is one visit of two orbits, non-CVZ because of the low-declination target. The optically bright star is acquired by direct imaging with the CCD and F25ND5 filter. The ACQ is followed by a medium-res FUV echelle exposure with setting E140M-1425 through the 0.2x0.2 photometric aperture, to fill out the first orbit. Second orbit begins with another medium-res FUV echelle exposure, again through the 0.2x0.2 slot. This represents a small change from the previous Cycles, when a pair of E140H exposures was used to cover much of the FUV range. However, detailed examination of the previous E140H spectra has shown that they are less optimum to capture the key, but faint, coronal forbidden lines of Fe XII at 124 nm and 134 nm. The pair of E140M exposures achieves higher sensitivity, and also expand the wavelength coverage, especially down to C III 117 nm, missed in the E140H strategy. At the end of the second orbit, a brief NUV high-res echelle exposure is taken with setting E230H-2713 to capture the important chromospheric emission doublet of Mg II at 280 nm. Owing to the brightness of Procyon at these wavelengths, the observation must be taken through the ND2 slit, which requires a prior peak-up (in dispersed light with G430M).

Non-standard lamp exposures, uniformly 45s, are used for all the FUV and NUV settings of all three stars to provide accurate zero-point wavelength shifts for the respective echellegrams. This is because the lamp output has faded over the years, and the default wavecals no longer are able to provide the desired accuracy. The deeper-than-normal wavecals ensure that the dispersion properties of the spectrometer are accurately monitored, to take full advantage of STIS's ability to measure small differential velocity shifts between emission lines formed in different environments in the stellar outer atmosphere, a major scientific goal of the project. The non-standard wavecals are forced to be adjacent to the respective science exposures by a "SEQ NON-INT" pairing. Because the GO-specified wavelength calibrations can substitute for the normal brief AUTO-WAVECALs, the latter are turned off in the respective science exposures.

Visit

Proposal 16254, Visit 10, implementation Wed Feb 03 18:00:16 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/NUV-MAMA, STIS/CCD, STIS/FUV-MAMA

Special Requirements: CVZ; ORIENT 49D TO 209 D; ORIENT 229D TO 359.99 D; ORIENT 0D TO 29 D

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HD128620	RA: 14 39 26.8500 (219.8618750d)	Proper Motion RA: -3.84 arcsec/yr	V=+0.01+/-0.1	Reference Frame: ICRS
	Alt Name1: ALP-CEN-A	Dec: -60 49 56.90 (-60.83247d)	Proper Motion Dec: +0.33 arcsec/yr		
		Equinox: J2000	Parallax: 0.747"		
			Epoch of Position: 2018.38		
			Radial Velocity: -24 km/sec		

Comments: Target coords for epoch 2018.38 were based on a global orbital + proper-motion + parallax fit to ten years of Chandra X-ray positions. Alpha Cen AB are moving past their close approach (on the sky), which occurred in 2016, consequently the relative orbital motion of A has a significant influence on its apparent proper motion.
Category=STAR
Description=[CORONA, G V-IV]
Extended=NO

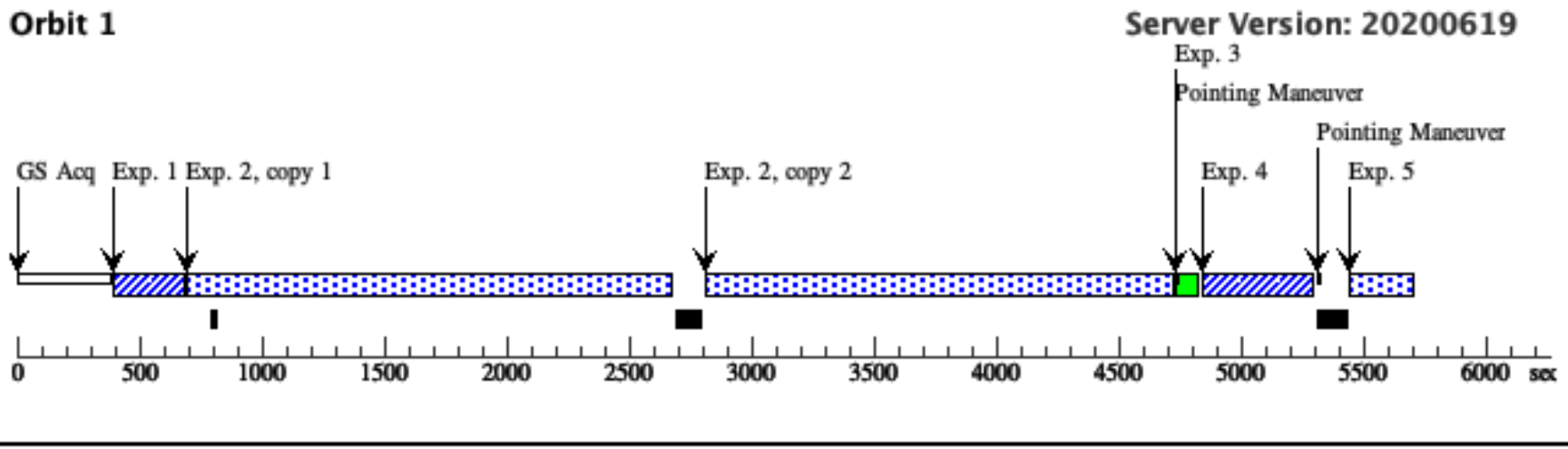
(2)	HD128621	Offset from HD128620		V=1.33+/-0.1	Offset Position (HD128621)
	Alt Name1: ALP-CEN-B	RA Offset: -0.08 Secs			
		Dec Offset: 6.4 Arcsec			

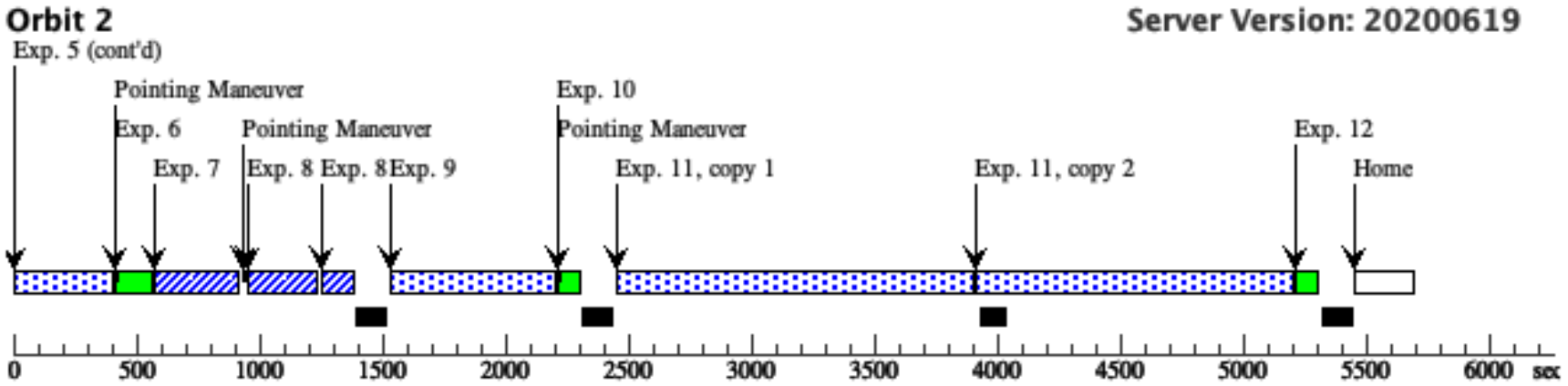
Comments: Offset of B relative to A, for 2020.5, was determined from the empirical ephemeris, designed to closely match the relative orbit as recorded by Chandra's High Resoultion Camera in recent years.
Category=STAR
Description=[CORONA, K V-IV]
Extended=NO

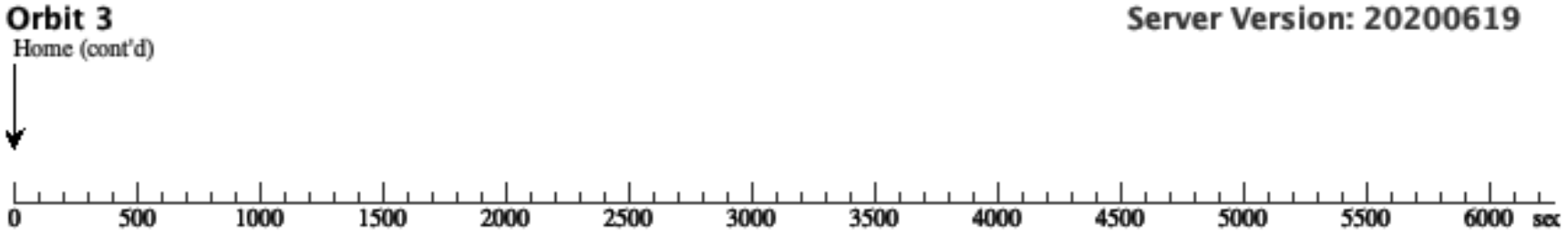
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.im.11 84308)	(1) HD128620	STIS/CCD, ACQ, F25ND5	MIRROR		GS ACQ SCENARIO BASE1BE		0.1 Secs (0.1 Secs) *[==>]*	***[1]***
	Comments: Castelli-Kurucz Models G2V 5750 4.5, renormalized to vegamag = 0.01 in filter Johnson/V: SNR~140 in 0.1 s; time to saturation 0.6 s.								
2	(STIS.sp.11 84381)	(1) HD128620	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A	WAVECAL=NO		Sequence 2-3 Non-Int in Visit 10	1900 Secs X 2 (3800 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]*	***[1]***
	Comments: Input=special ETC file for ALP-CEN-A from previous STIS echelle spectra; exposure time= 1.5 ks at Si IV 139 nm gives peak SNR~40 (per resol) with 0.2x0.2 aperture. No LCR or GCR issues.								
3		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A			Sequence 2-3 Non-Int in Visit 10	45 Secs (45 Secs) *[==>]*	***[1]***
	Comments: Deeper than normal wavecal to determine accurate zero-point shift.								
4	(STIS.sp.11 84256)	(1) HD128620	STIS/CCD, ACQ/PEAK, 31X0.05NDC	G430M 4451 A				0.1 Secs (0.1 Secs) *[==>]*	***[1]***
	Comments: Dispersed light peak-up; Castelli-Kurucz Model G2V 5750 4.5, renormalized to vegamag = 0.01 in filter Johnson/V: in 0.1 s with NDA, GCR= 2780k e-.								
5	(STIS.sp.11 84194)	(1) HD128620	STIS/NUV-MAMA, ACCUM, 31X0.05NDC	E230H 2713 A	WAVECAL=NO		Sequence 5-6 Non-Int in Visit 10	500 Secs (500 Secs) *[==>]*	***[1]***
	Comments: ETC GCR~135k for Castelli-Kurucz Model G2V 5750 4.5, renormalized to vegamag = 0.01 in filter Johnson/V. Measured GCR~110k for several exposures in similar setting H-2812 with NDC; H-2713 GCR should be less because NUV continuum is falling toward shorter wavelengths.								
6		WAVE	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A			Sequence 5-6 Non-Int in Visit 10	45 Secs (45 Secs) *[==>]*	***[2]***
	Comments: Deeper than normal wavecal to determine accurate zero-point shift.								
7	(STIS.im.11 84300)	(2) HD128621	STIS/CCD, ACQ, F25ND5	MIRROR				0.1 Secs (0.1 Secs) *[==>]*	***[2]***
	Comments: Castelli-Kurucz Models K2V 4750 4.5, renormalized to vegamag = 1.33 in filter Johnson/V: SNR~74 in 0.1 s; time to saturation 1.7 s.								
8	(STIS.sp.11 84373)	(2) HD128621	STIS/CCD, ACQ/PEAK, 0.2X0.09	G430M 3936 A				0.1 Secs (0.1 Secs) *[==>]*	***[2]***
	Comments: Dispersed light peak-up; Castelli-Kurucz Models K2V 4750 4.5, renormalized to vegamag = 1.33 in filter Johnson/V: 5470k e- in 0.1 s; time to saturation 0.9 s.								
9	(STIS.sp.11 84211)	(2) HD128621	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A	WAVECAL=NO		Sequence 9-10 Non-Int in Visit 10	500 Secs (500 Secs) *[==>]*	***[2]***
	Comments: GCR= 73k from ETC run for Castelli-Kurucz Model K2V 4750 4.5, renormalized to vegamag = 1.33 in filter Johnson/V. Variability expected to be very low in the K-dwarf continuum, which dominates the H-2713 setting. Measured GCRs from ocre10050, ocre11050, octr10050, and od5c10050 (same setting and slit) are 126k+/-13k.								
10		WAVE	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A			Sequence 9-10 Non-Int in Visit 10	45 Secs (45 Secs) *[==>]*	***[2]***
	Comments: Deeper than normal wavecal to determine accurate zero-point shift.								
11	(STIS.sp.11 84375)	(2) HD128621	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A	WAVECAL=NO		Sequence 11-12 Non-Int in Visit 10	1280 Secs X 2 (2560 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]*	***[2]***
	Comments: Based on new FUV spectrum of ALP-CEN-B from 4 years of STIS measurements. No LCR or GCR issues.								
12		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A			Sequence 11-12 Non-Int in Visit 10	45 Secs (45 Secs) *[==>]*	***[2]***
	Comments: Deeper than normal wavecal to determine accurate zero-point shift.								

Orbit Structure







Visit

Proposal 16254, Visit 11, implementation Wed Feb 03 18:00:17 GMT 2021

Diagnostic Status: Warning

Scientific Instruments: STIS/NUV-MAMA, STIS/CCD, STIS/FUV-MAMA

Special Requirements: (none)

Diagnostics

(Visit 11) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	HD61421	RA: 07 39 17.1867 (114.8216113d)	Proper Motion RA: -0.7146 arcsec/yr	V=0.37+/-0.1	Reference Frame: ICRS
	Alt Name1: ALPHA-CMI	Dec: +05 13 9.74 (5.21937d)	Proper Motion Dec: -1.0368 arcsec/yr		
	Alt Name2: PROCYON	Equinox: J2000	Parallax: 0.285"		
			Epoch of Position: 2019.50		
			Radial Velocity: -3.2 km/sec		

Comments: Target coords for epoch 2019.5 were taken from SIMBAD, in ICRS frame.
Category=STAR
Description=[CORONA, F3-F9]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.im.1184316)	(3) HD61421	STIS/CCD, ACQ, F25ND5	MIRROR		GS ACQ SCENARIO BASE1BE		0.1 Secs (0.1 Secs)	
								[==>]	***[1]***
Comments: Castelli-Kurucz Model F5V 6500 4.0, renormalized to vegamag = 0.37 in filter Johnson/V: SNR~110 in 0.1 s; time to saturation 0.9 s.									
2	(STIS.sp.1184382)	(3) HD61421	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A	WAVECAL=NO		Sequence 2-3 Non-Int in Visit 11	2355 Secs (2355 Secs)	
								[==>]	***[1]***
Comments: Input=special ETC file for ALP-CMI from previous STIS echelle spectra; exposure time= 2 ks at Si IV 139 nm gives peak SNR~30 (per resol) with 0.2x0.2 aperture. No LCR or GCR issues									
3		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A			Sequence 2-3 Non-Int in Visit 11	45 Secs (45 Secs)	
								[==>]	***[1]***
Comments: Deeper than normal wavecal to determine accurate zero-point shift.									
4	(STIS.sp.1184382)	(3) HD61421	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A	WAVECAL=NO			1316 Secs (1316 Secs)	
								[==>]	***[2]***
Comments: Input=special ETC file for ALP-CMI from previous STIS echelle spectra; exposure time= 2 ks at Si IV 139 nm gives peak SNR~30 (per resol) with 0.2x0.2 aperture. No LCR or GCR issues									
5	(STIS.sp.1184260)	(3) HD61421	STIS/CCD, ACQ/PEAK, 0.2X0.05ND	G430M 4451 A				0.1 Secs (0.1 Secs)	
								[==>]	***[2]***
Comments: Dispersed light peak-up for Castelli-Kurucz Model F5V 6500 4.0, renormalized to vegamag = 0.37 in filter Johnson/V: in 0.1 s, 477k e- with ND2 slit.									
6	(STIS.sp.1184232)	(3) HD61421	STIS/NUV-MAMA, ACCUM, 0.2X0.05ND	E230H 2713 A	WAVECAL=NO		Sequence 6-7 Non-Int in Visit 11	500 Secs (500 Secs)	
								[==>]	***[2]***
Comments: Input=special ETC file for ALP-CMI from previous STIS echelle spectra; exposure time= 500 s at Mg II 279 nm gives peak SNR~30 (per resol) with ND2 aperture. No LCR or GCR issues. (ETC GCR ~60 k; but, ~40k as measured from raw images in similar settings, also with ND2).									
7		WAVE	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A			Sequence 6-7 Non-Int in Visit 11	45 Secs (45 Secs)	
								[==>]	***[2]***
Comments: Deeper than normal wavecal to determine accurate zero-point shift.									

Orbit Structure