



## 16787 - Cycles and the Seven Dwarfs

Cycle: 29, Proposal Category: GO

(Availability Mode: SUPPORTED)

### INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
<b>Dr. Thomas R. Ayres (PI) (Contact)</b>	<b>University of Colorado at Boulder</b>	<b>thomas.ayres@colorado.edu</b>

### VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
10	(1) HD-131156A (2) HD-131156B	COS/FUV COS/NUV	2	28-Oct-2022 12:02:27.0	yes
11	(3) HD-165341A (4) HD-165341B	COS/FUV COS/NUV	2	28-Oct-2022 12:02:29.0	yes
12	(3) HD-165341A (4) HD-165341B	COS/FUV COS/NUV	2	28-Oct-2022 12:02:32.0	yes

6 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 equivalent, 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 addition to earlier long-term joint Chandra/HST programs (previously involving Alpha Cen [G2V+K1V] and Procyon [F5IV]), will be carried out for two new targets, the nearby binaries Xi Bootis (G8V+K4) and 70 Ophiuchi (K0V+K5V).

The HST part of the program will measure FUV subcoronal ( $T \sim 100,000$  K) emission lines, like Si IV 140 nm, C IV 155 nm, and density-sensitive O IV 140 nm, as well as important chromospheric ( $T \sim 10,000$  K) features, like O I 130 nm, C II 133 nm, and C I 165 nm, in both pairs of stars, with one COS visit per system each year. Analyses of these emissions, including dynamical information encoded in Doppler shifts and distortions of the line shapes, can provide insight concerning the thermal/pressure structure of the anomalously hot outer layers of these stars; and how these structural properties change with the ebb and flow of a magnetic activity cycle.

## **OBSERVING DESCRIPTION**

### **\*\*Impact of Reduced Gyro Mode\*\***

-----  
The two targets, Xi Boo and 70 Oph, would be minimally affected by RGM, because there is only a minor orientation constraint on the observations (having to do with protecting the PSA for the NUV/BOA target acquisition). Further, the Visits are only 2 orbits, minimizing the possibility of re-acquisition failures. However, if target acquisition times are increased by RGM, 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)

Observational goal is to obtain FUV moderate-resolution spectra of both components of Xi Boo and 70 Oph using Cosmic Origins Spectrograph (COS). The primaries, Xi Boo A and 70 Oph A, are nearly identical in FUV flux levels, about a tenth of well-studied (by STIS) Alpha Cen A. Normally, high-sensitivity COS would be off-limits for these primaries, because their strong Lyman-alpha features would violate FUV detector bright limits. However, the COS G130M-1222 setting places Lyman-alpha in the gap between detector sides A and B, so can be used for cool stars, as long as their other strong emissions (e.g., C II 133 nm) are "safe" (as is the case for Xi Boo A and 70 Oph A). When combined with COS G160M-1533, the spectral range 107-171 nm can be covered, with only two small gaps: 120.7-122.3 nm (Lyman-alpha) and 151.5-153.3 nm (devoid of important lines). COS's 15 km/s resolution is fully adequate for the relatively broad FUV emission features of these cool stars, especially the "hot" lines like Si III 120.6 nm ( $T \sim 30,000$  K), Si IV 139.3 nm (80,000 K), and C IV 154.8 nm (100,000 K). The COS FUV channel is so sensitive that a mere 1000 s exposure obtains  $S/N \sim 100$  (line peak) at Si III, 80 at Si IV, and 65 at C IV, for both primary stars. Each grating setting requires 4 "FP-Splits" to mitigate fixed pattern noise.

The pair of FUV settings plus FP-SPLITs can be done in a single orbit for the primary of each system, including the initial Guide Star and NUV imaging target acquisitions.

At the beginning of the second orbit, the secondary star would be centered by a small offset maneuver from the primary, given the accurate orbital ephemeris. The same dual-setting FUV sequence then would be carried out, extending over the remaining unocculted part of the second orbit.

The COS visits would be once a year for each system (4 HST orbits per year, total): experience with Alpha Cen AB has shown that the FUV variability, while significant, is not as pronounced as that of the X-rays (which are observed twice a year for each system). Helpfully, key coronal forbidden lines Fe XII 134.9 nm (T~2 MK) and Fe XXI 135.4 nm (10 MK) are available in the FUV to assess the stellar coronal states at the times of the COS pointings. For this reason, the HST and Chandra observations need not be simultaneous. In fact, it is better to have them separated, since the FUV coronal forbidden lines would then provide an additional point on the high-energy timeline. Given the very deep COS exposures proposed here (especially at 134.9 nm and 135.4 nm, which receive double coverage in the 2 nm overlap between G130M and G160M), these coronal forbidden lines should be easily detectable in the primary stars (based on previous STIS experience), and perhaps even in the UV-fainter secondaries.

# Proposal 16787 - Visit 10 - Cycles and the Seven Dwarfs

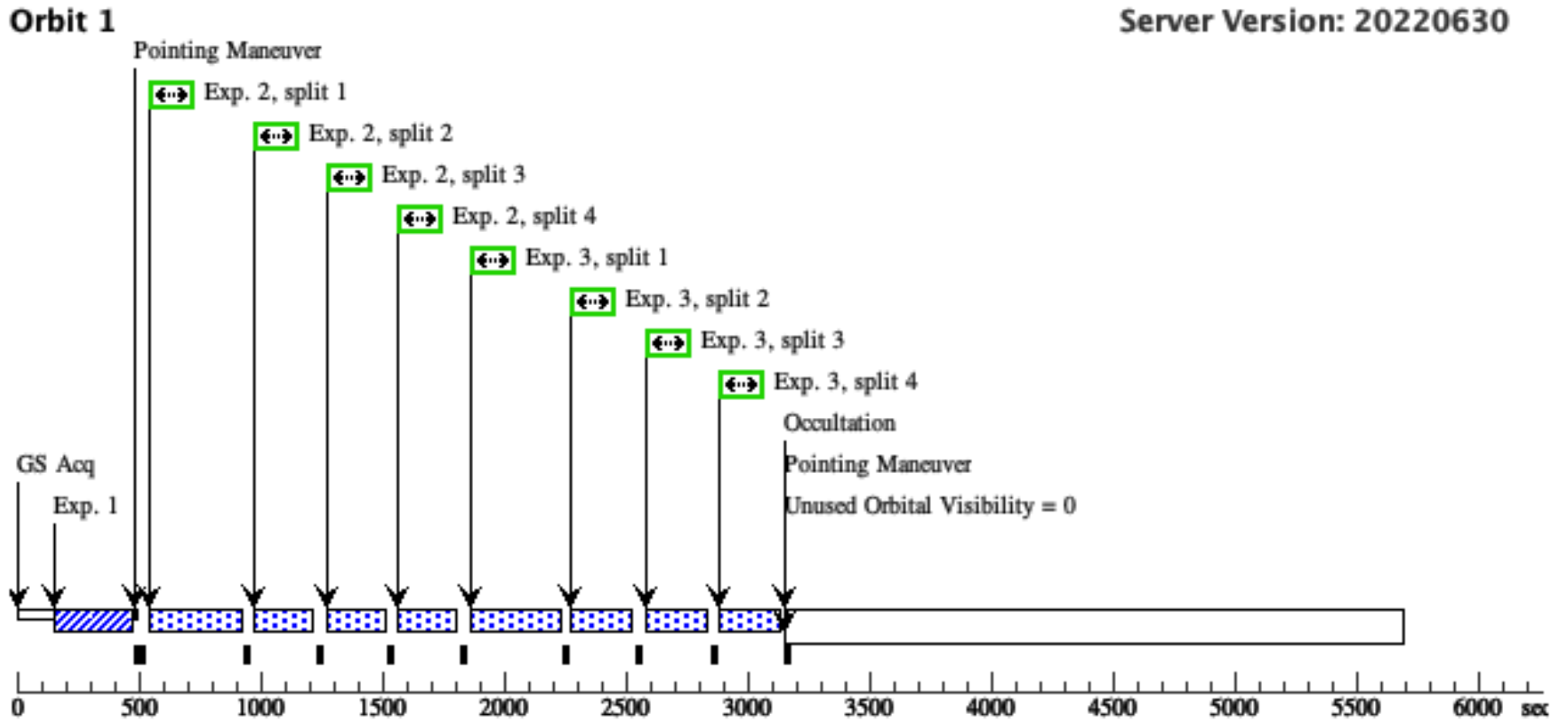
Fri Oct 28 16:02:32 GMT 2022

Visit	Proposal 16787, Visit 10, completed Diagnostic Status: No Diagnostics Scientific Instruments: COS/FUV, COS/NUV Special Requirements: ORIENT 131D TO 11 D					
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes
		(1)	HD-131156A Alt Name1: XI-BOO-A	RA: 14 51 23.3880 (222.8474500d) Dec: +19 06 1.64 (19.10046d) Equinox: J2000	Proper Motion RA: +0.128 arcsec/yr Proper Motion Dec: -0.042 arcsec/yr Parallax: 0.149" Epoch of Position: 2000 Radial Velocity: +1.5 km/sec	V=+4.68+/-0.1
	<i>Comments: Target coords for epoch 2000 from SIMBAD, based on Gaia measurements for a mean epoch of 2015.5 corrected for Gaia proper motions</i> Category=STAR Description=[CORONA, G V-IV] Extended=NO					
	(2)	HD-131156B Alt Name1: XI-BOO-B	Offset from HD-131156A RA Offset: -0.325 Secs Dec Offset: 2.03 Arcsec	Radial Velocity: +2.3 km/sec	V=+6.82+/-0.1	Offset Position (HD-131156B)
	<i>Comments: Target offset based on orbital model, good for 2021 +/- 1 yr</i> Category=STAR Description=[CORONA, K V-IV] Extended=NO					

Proposal 16787 - Visit 10 - Cycles and the Seven Dwarfs

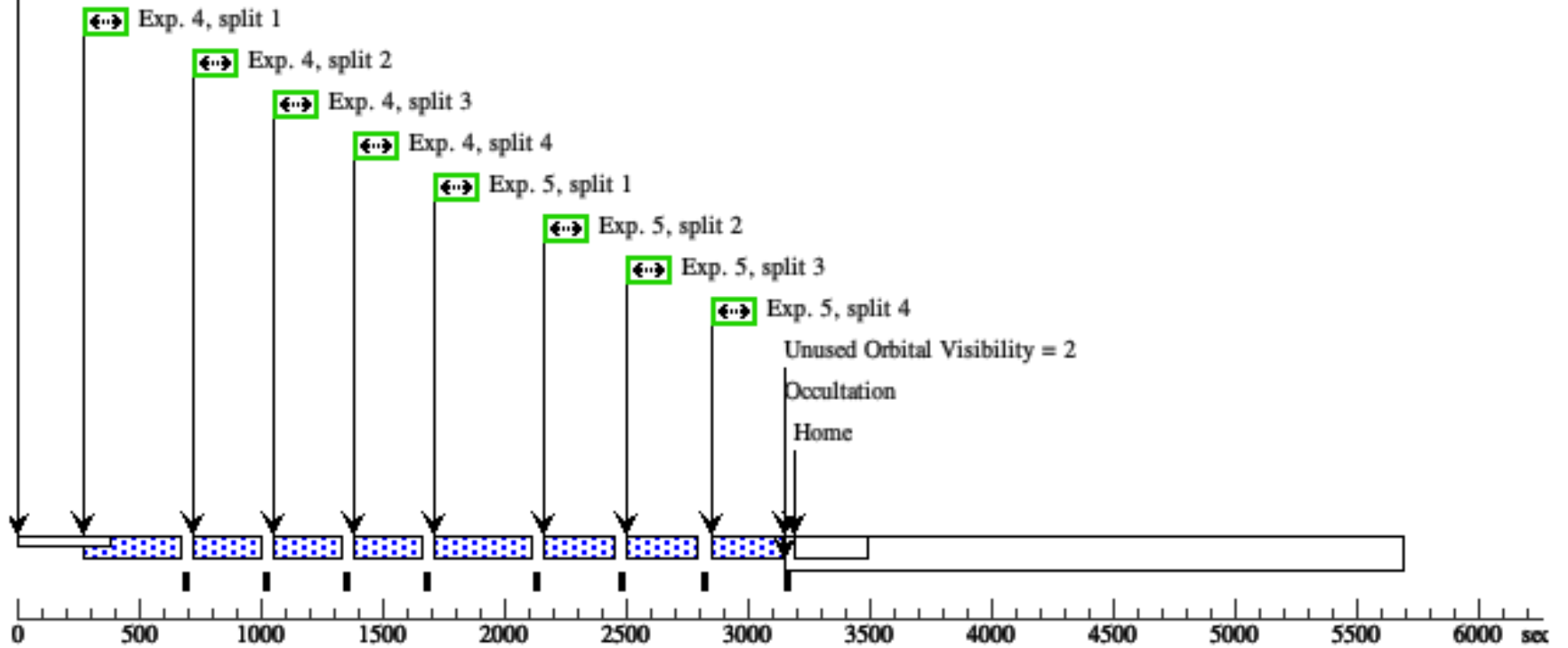
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit	
	1	(COS.ta.136 7079)	(1) HD-131156A	COS/NUV, ACQ/IMAGE, BOA	MIRRORB			GS ACQ SCENARI O BASE1BE		11 Secs (11 Secs) [==>]	[1]
	<i>Comments: Castelli-Kurucz Models G8V, renormalized to vegamag = 4.68 in filter Johnson/V</i>										
	2	(COS.sp.136 7281)	(1) HD-131156A	COS/FUV, TIME-TAG, PSA	G130M 1222 A		BUFFER-TIME=24 00; FP-POS=ALL			190 Secs (760 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]
	<i>Comments: h_hd131156_uvsum_1m_51163_etc.dat from StarCAT (STIS E140M-1425)</i>										
3	(COS.sp.136 7282)	(1) HD-131156A	COS/FUV, TIME-TAG, PSA	G160M 1533 A		BUFFER-TIME=40 00; FP-POS=ALL			200 Secs (800 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]	
<i>Comments: h_hd131156_uvsum_1m_51163_etc.dat from StarCAT (STIS E140M-1425)</i>											
4	(COS.sp.136 7319)	(2) HD-131156B	COS/FUV, TIME-TAG, PSA	G130M 1222 A		BUFFER-TIME=93 00; FP-POS=ALL			225 Secs (900 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[2]	
<i>Comments: B fluxes scaled by 0.14 from A [h_hd131156_uvsum_1m_51163_etc.dat from StarCAT (STIS E140M-1425)]</i>											
5	(COS.sp.136 7320)	(2) HD-131156B	COS/FUV, TIME-TAG, PSA	G160M 1533 A		BUFFER-TIME=13 400; FP-POS=ALL			237 Secs (948 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[2]	
<i>Comments: B fluxes scaled by 0.14 from A [h_hd131156_uvsum_1m_51163_etc.dat from StarCAT (STIS E140M-1425)]</i>											

Orbit Structure



**Orbit 2**

GS Reacq

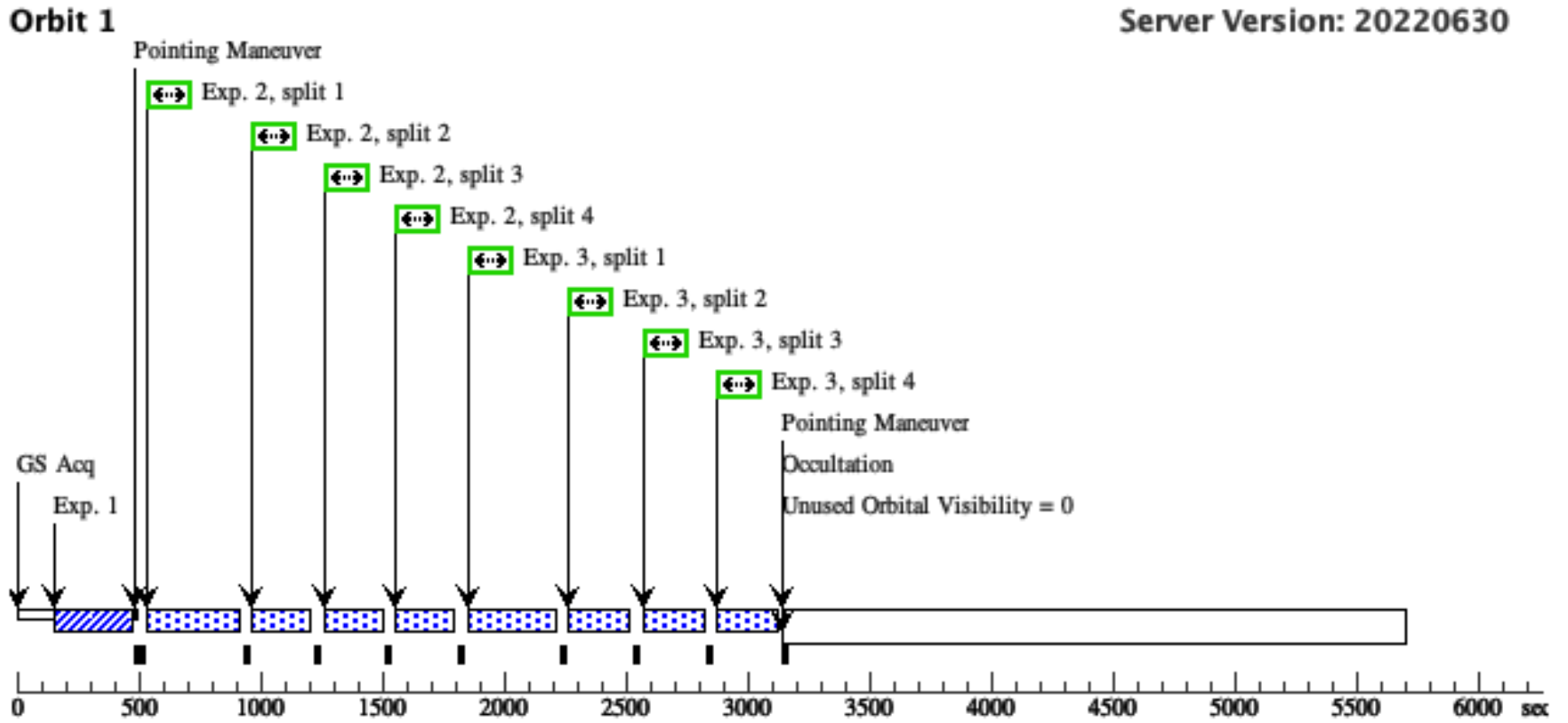


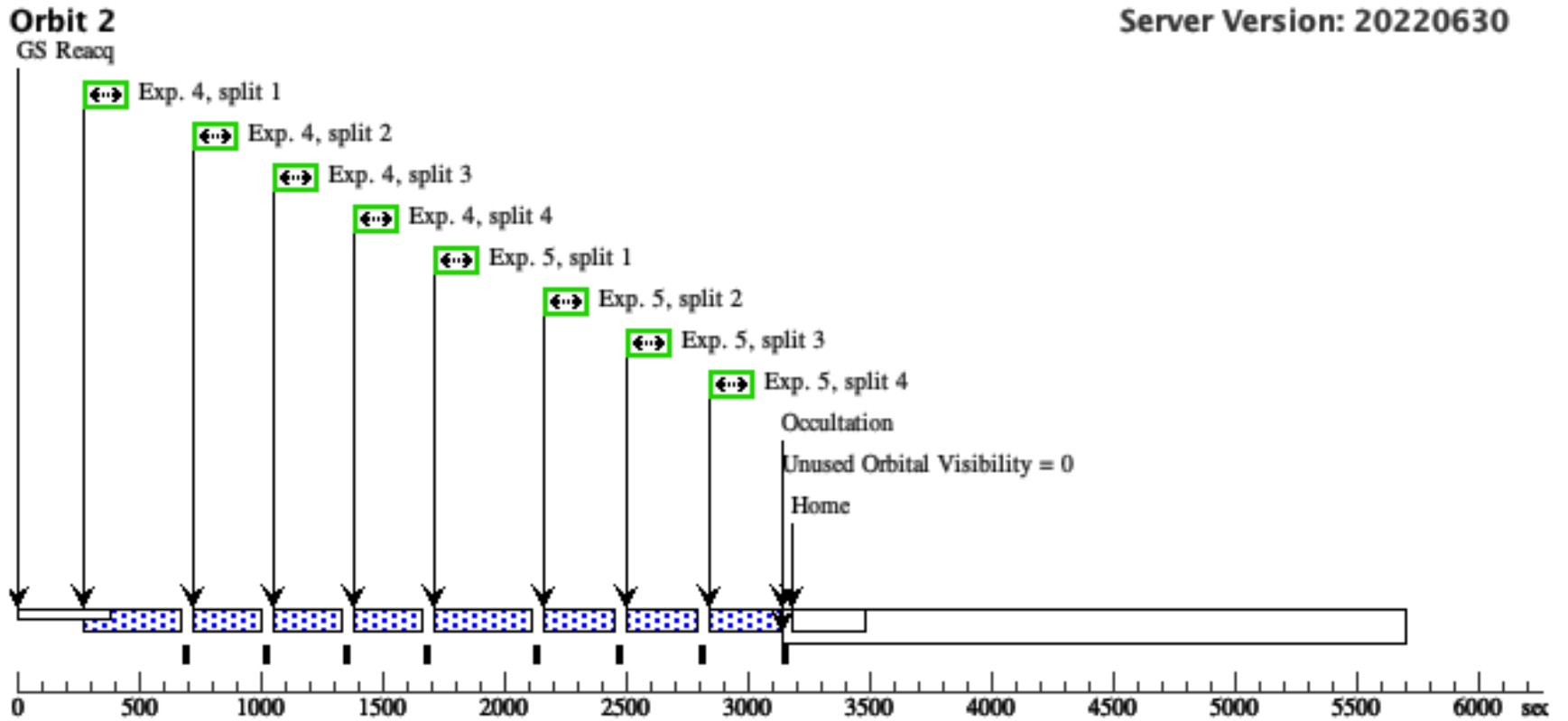
# Proposal 16787 - Visit 11 - Cycles and the Seven Dwarfs

Fri Oct 28 16:02:32 GMT 2022

Visit	<b>Proposal 16787, Visit 11, failed</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: ORIENT 316D TO 196 D									
	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
Fixed Targets	(3)	HD-165341A Alt Name1: 70-OPH-A	RA: 18 05 27.4620 (271.3644250d) Dec: +02 29 43.36 (2.49538d) Equinox: J2000	Proper Motion RA: +0.124 arcsec/yr Proper Motion Dec: -0.963 arcsec/yr Parallax: 0.149" Epoch of Position: 2015.5 Radial Velocity: -6.9 km/sec	V=+4.03+/-0.1	Reference Frame: ICRS				
	<i>Comments: Target coords based on Gaia measurements for a mean epoch of 2015.5 (no proper motions cited in DR2); proper motions from Hipparcos.</i> Category=STAR Description=[CORONA, K V-IV] Extended=NO									
Fixed Targets	(4)	HD-165341B Alt Name1: 70-OPH-B	Offset from HD-165341A RA Offset: 0.388 Secs Dec Offset: -3.31 Arcsec	Radial Velocity: -10.0 km/sec	V=+6.07+/-0.1	Offset Position (HD-165341B)				
	<i>Comments: Target offset based on orbital model, good for 2021 +/- 1 yr</i> 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	(COS.ta.136 7302)	(3) HD-165341A	COS/NUV, ACQ/IMAGE, BOA	MIRRORB		GS ACQ SCENARI O BASE1BE		8 Secs (8 Secs) [==>]	[1]
	<i>Comments: Castelli-Kurucz Models K0V, renormalized to vegamag = 4.22 in filter Johnson/V (from BSC and WDS)</i>									
	2	(COS.sp.136 7312)	(3) HD-165341A	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=28 00; FP-POS=ALL			189 Secs (756 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]
	3	(COS.sp.136 7313)	(3) HD-165341A	COS/FUV, TIME-TAG, PSA	G160M 1533 A	BUFFER-TIME=43 00; FP-POS=ALL			199 Secs (796 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]
	4	(COS.sp.136 7325)	(4) HD-165341B	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=92 00; FP-POS=ALL			225 Secs (900 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[2]
5	(COS.sp.136 7326)	(4) HD-165341B	COS/FUV, TIME-TAG, PSA	G160M 1533 A	BUFFER-TIME=12 700; FP-POS=ALL			234 Secs (936 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[2]	

Orbit Structure





Proposal 16787 - HOPR 11 (12) - Cycles and the Seven Dwarfs

Fri Oct 28 16:02:33 GMT 2022

Visit	<b>Proposal 16787, HOPR_11 (12)</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: ORIENT 316D TO 196 D										
	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous					
Fixed Targets	(3)	HD-165341A Alt Name1: 70-OPH-A	RA: 18 05 27.4620 (271.3644250d) Dec: +02 29 43.36 (2.49538d) Equinox: J2000	Proper Motion RA: +0.124 arcsec/yr Proper Motion Dec: -0.963 arcsec/yr Parallax: 0.149" Epoch of Position: 2015.5 Radial Velocity: -6.9 km/sec	V=+4.03+/-0.1	Reference Frame: ICRS					
	<i>Comments: Target coords based on Gaia measurements for a mean epoch of 2015.5 (no proper motions cited in DR2); proper motions from Hipparcos.</i> Category=STAR Description=[CORONA, K V-IV] Extended=NO										
Fixed Targets	(4)	HD-165341B Alt Name1: 70-OPH-B	Offset from HD-165341A RA Offset: 0.388 Secs Dec Offset: -3.31 Arcsec	Radial Velocity: -10.0 km/sec	V=+6.07+/-0.1	Offset Position (HD-165341B)					
	<i>Comments: Target offset based on orbital model, good for 2021 +/- 1 yr</i> 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	(COS.ta.136 7302)	(3) HD-165341A	COS/NUV, ACQ/IMAGE, BOA	MIRRORB		GS ACQ SCENARI O BASE1BE		8 Secs (8 Secs) [==>]	[1]	
	<i>Comments: Castelli-Kurucz Models K0V, renormalized to vegamag = 4.22 in filter Johnson/V (from BSC and WDS)</i>										
	2	(COS.sp.136 7312)	(3) HD-165341A	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=28 00; FP-POS=ALL			189 Secs (756 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]	
	3	(COS.sp.136 7313)	(3) HD-165341A	COS/FUV, TIME-TAG, PSA	G160M 1533 A	BUFFER-TIME=43 00; FP-POS=ALL			199 Secs (796 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]	
	4	(COS.sp.136 7325)	(4) HD-165341B	COS/FUV, TIME-TAG, PSA	G130M 1222 A	BUFFER-TIME=92 00; FP-POS=ALL			225 Secs (900 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[2]	
5	(COS.sp.136 7326)	(4) HD-165341B	COS/FUV, TIME-TAG, PSA	G160M 1533 A	BUFFER-TIME=12 700; FP-POS=ALL			234 Secs (936 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[2]		

Orbit Structure

Orbit 1

