11726 - Mysteries of the North Star: HST/COS confirmation of real-time evolution and upper atmospheric heating in Polaris

Cycle: 17, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Edward F. Guinan (PI)	**Villanova University**	**edward.guinan@villanova.edu**
Mr. Scott G. Engle (CoI) (Contact)	Villanova University	scott.engle@villanova.edu
Dr. Nancy R. Evans (CoI)	Smithsonian Institution Astrophysical Observatory	nevans@cfa.harvard.edu
Dr. Edward L. Fitzpatrick (CoI)	Villanova University	fitz@ast.villanova.edu

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) POLARIS	COS/FUV COS/NUV	2	01-Jul-2009 21:23:37.0	yes
02	(1) POLARIS	COS/FUV COS/NUV	2	01-Jul-2009 21:23:53.0	yes

4 Total Orbits Used

ABSTRACT

The major aims of this proposal are twofold: to confirm and understand the recently observed apparent evolutionary changes of the bright (3.97-day) Cepheid Polaris – and – to further study the recent discovery of hot plasmas (up to 1MK) well above the photospheric temperature of the Cepheid

itself. This study will have a major impact on understanding the evolution, structure, heating and dynamics of Cepheid (and related Hybrid Star) atmospheres. In our study – the Secret Lives of Cepheids – Polaris is noteworthy for its well-documented increase in pulsation period (+3.51 sec/year) and decrease in light amplitude over the last 100-150 years, almost ceasing pulsations in the early 1990s. Moreover, our studies of photoelectric photometry and historic visual observations have shown evidence that Polaris may have increased in brightness by almost 0.2-mag over the past century (and possibly by more than 1-mag since Ptolemy). In addition, a study of the IUE database indicates a possible increase in photospheric temperature (which the FUV region is very sensitive to) between 1978/79 and 1991/93, pointing to a change of ~35+/-12 K. More recently, FUSE and Chandra observations of Polaris indicate the presence of C III 977/1176A and O VI 1032/1038A emissions, as well as possible soft X-ray emission, respectively. The source of these hot plasmas could be related to pulsations (shock heating) and/or magnetic activity. To further investigate the evolutionary changes and upper atmospheric emissions of Polaris, we propose for HST/COS medium resolution spectrometry covering the wavelength range ~1150–2100A. This wavelength range covers both the high energy emission lines (<1600A) along with the rise in continuum of the F-supergiant photosphere (>1600A). HST/COS is the only instrument capable of carrying out the necessary FUV observations to achieve our scientific goals for Polaris – providing a better understanding of the evolution and heating mechanisms of Cepheids.

OBSERVING DESCRIPTION

For all exposure time calculations IUE spectra were originally used as input, and were then re-run with a Pickles model (F8 I) scaled to Polaris' current brightness (~1.97-mag) to ensure accuracy. To cover the shortest wavelengths (~1150–1450Å), we will observe with the COS G130M (central wave. = 1291Å) grating (Primary Science Aperture – PSA) for 2591 seconds (~1 full orbit after overheads), resulting in S/N values of more than ~30 over the wavelength range. The G160M (1589Å) grating (PSA) will then cover the ~1395–1760Å region, and a 1500 second exposure will return S/N values of more than ~35. Four separate exposures with the G185M grating (PSA) will then cover ~1800–2100Å. Exposure times of: (central wave. = 1913Å) 200-sec, (1941Å) 193-sec, (1971Å) 192-sec and (1986Å) 190-sec will achieve S/N values greater than ~40 for the entire wavelength range. This proposal is requesting 2 orbits each at Polaris' maximum and minimum phase. In each visit, one orbit will be used to obtain the G130M exposure, and the other orbit will obtain the G160M & G185M exposures.

ADDITIONAL COMMENTS

In order to further study the possible brightening of Polaris, and to better understand its chromospheric/transition region emissions, we propose for COS medium resolution observations near the maximum (phase ~ 0.0 +/- 0.05) and minimum (~0.5 +/- 0.05) of Polaris' pulsational phase. This will allow us to assess any variability in either UV continuum or emission lines fluxes, and calculate mean values for comparison with archival IUE observations.

We are using the following ephemeris:
2452366.665 + 3.9726772(E)

Visit

Proposal 11726, Visit 01, implementation Thu Jul 02 01:23:58 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/NUV, COS/FUV

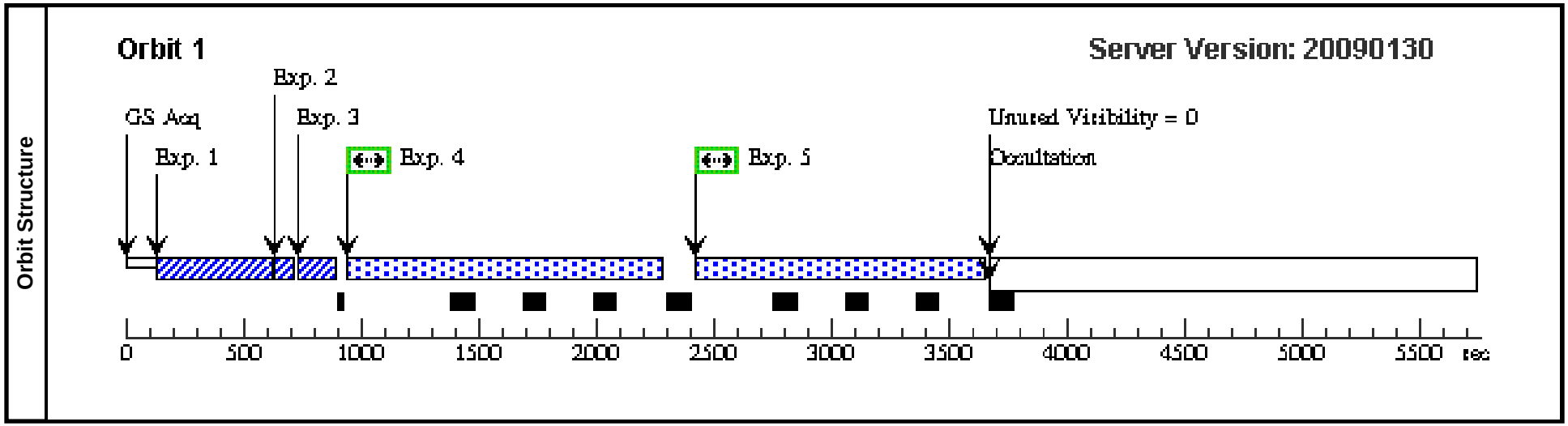
Special Requirements: Period 3.97209 D AND ZERO-PHASE HJD2454340.754

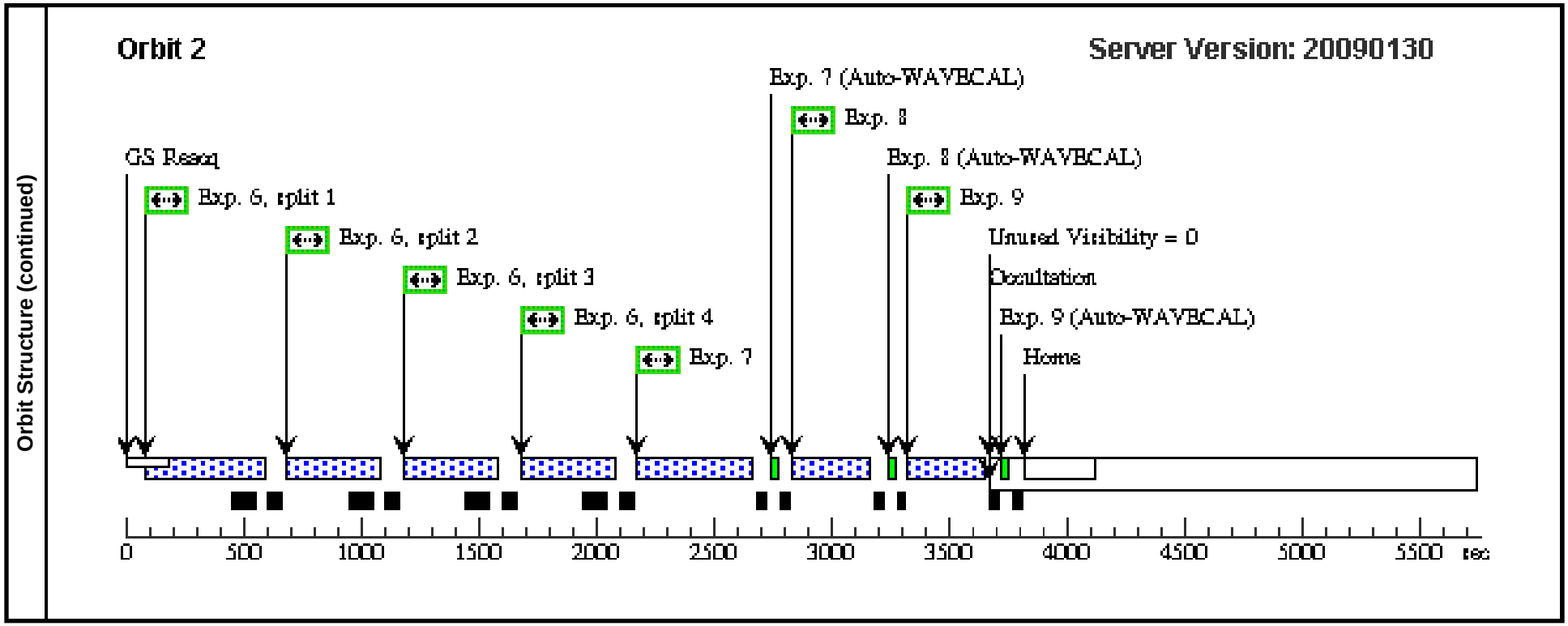
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POLARIS	RA: 02 31 49.0837 (37.9545154d) Dec: +89 15 50.79 (89.26411d) Equinox: J2000		V=1.98+/-0.04	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) POLARIS	COS/NUV, ACQ/SEARCH, PSA	G185M 1921 A	STEP-SIZE=1.767; SCAN-SIZE=3	PHASE 0.95 TO 0.05		1 Secs *[==>]*	 ***[1]***
2		(1) POLARIS	COS/NUV, ACQ/PEAKXD, PSA	G185M 1921 A				3 Secs *[==>]*	 ***[1]***
3		(1) POLARIS	COS/NUV, ACQ/PEAKD, PSA	G185M 1921 A	STEP-SIZE=1.2			1 Secs *[==>]*	 ***[1]***
4		(1) POLARIS	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=302; FLASH=YES; FP-POS=3			3000 Secs *[==>1184.0 Secs]*	 ***[1]***
5		(1) POLARIS	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=302; FLASH=YES; FP-POS=4			3000 Secs *[==>1180.0 Secs]*	 ***[1]***
6		(1) POLARIS	COS/FUV, TIME-TAG, PSA	G160M 1589 A	FLASH=YES; BUFFER-TIME=230; FP-POS=AUTO			1500 Secs *[==>350.0 Secs (Split 1)]* *[==>350.0 Secs (Split 2)]* *[==>350.0 Secs (Split 3)]* *[==>350.0 Secs (Split 4)]*	 ***[2]***
7		(1) POLARIS	COS/NUV, ACCUM, PSA	G185M 1913 A				200 Secs *[==>243.0 Secs]*	 ***[2]***
8		(1) POLARIS	COS/NUV, ACCUM, PSA	G185M 1941 A				200 Secs *[==>244.0 Secs]*	 ***[2]***
9		(1) POLARIS	COS/NUV, ACCUM, PSA	G185M 1882 A				200 Secs *[==>243.0 Secs]*	 ***[2]***


Orbit Structure
Orbit 1
Server Version: 20090130
GS Acq
Exp. 1
Exp. 2
Exp. 3
Exp. 4
Exp. 5
Unused Visibility = 0
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 2
Server Version: 20090130
GS Reacq
Exp. 6, split 1
Exp. 6, split 2
Exp. 6, split 3
Exp. 6, split 4
Exp. 7
Exp. 7 (Auto-WAVECAL)
Exp. 8
Exp. 8 (Auto-WAVECAL)
Exp. 9
Unused Visibility = 0
Occultation
Exp. 9 (Auto-WAVECAL)
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 11726, Visit 02, implementation Thu Jul 02 01:24:00 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/NUV, COS/FUV

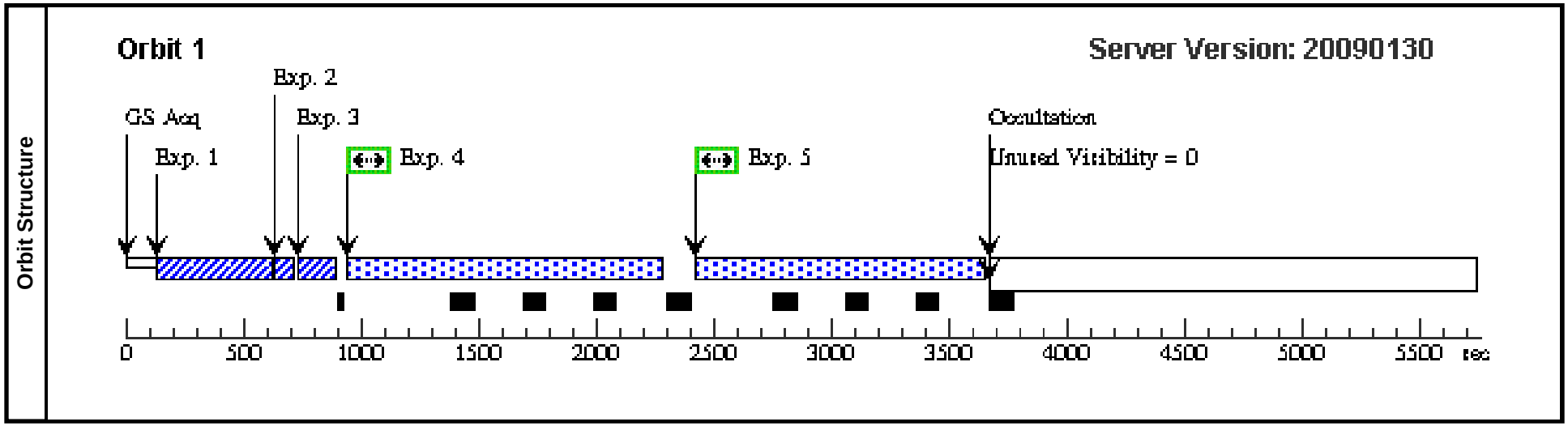
Special Requirements: Period 3.97209 D AND ZERO-PHASE HJD2454340.754

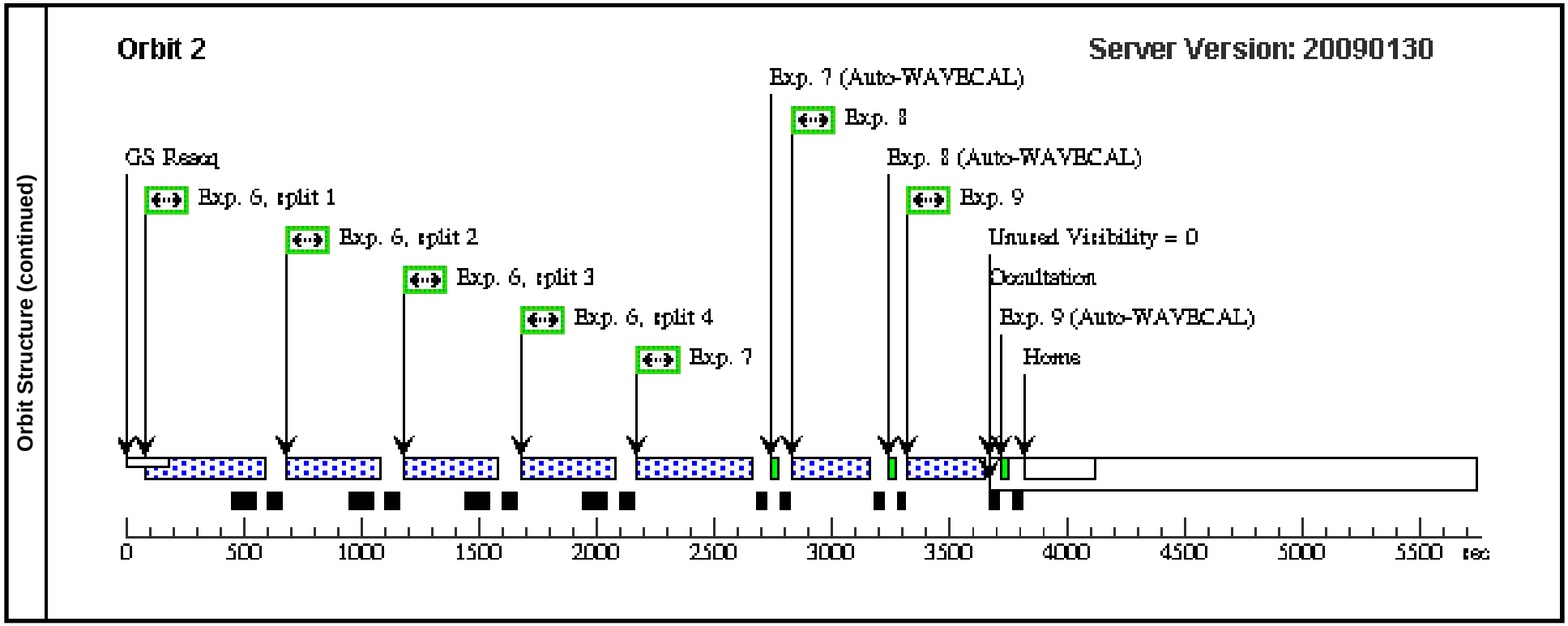
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POLARIS	RA: 02 31 49.0837 (37.9545154d) Dec: +89 15 50.79 (89.26411d) Equinox: J2000		V=1.98+/-0.04	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) POLARIS	COS/NUV, ACQ/SEARCH, PSA	G185M 1921 A	STEP-SIZE=1.767; SCAN-SIZE=3	PHASE 0.45 TO 0.55		1 Secs *[==>]*	 ***[1]***
2		(1) POLARIS	COS/NUV, ACQ/PEAKXD, PSA	G185M 1921 A				3 Secs *[==>]*	 ***[1]***
3		(1) POLARIS	COS/NUV, ACQ/PEAKD, PSA	G185M 1921 A	STEP-SIZE=1.2			1 Secs *[==>]*	 ***[1]***
4		(1) POLARIS	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=302; FLASH=YES; FP-POS=3			3000 Secs *[==>1184.0 Secs]*	 ***[1]***
5		(1) POLARIS	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=302; FLASH=YES; FP-POS=4			3000 Secs *[==>1180.0 Secs]*	 ***[1]***
6		(1) POLARIS	COS/FUV, TIME-TAG, PSA	G160M 1589 A	FLASH=YES; BUFFER-TIME=230; FP-POS=AUTO			1500 Secs *[==>350.0 Secs (Split 1)]* *[==>350.0 Secs (Split 2)]* *[==>350.0 Secs (Split 3)]* *[==>350.0 Secs (Split 4)]*	 ***[2]***
7		(1) POLARIS	COS/NUV, ACCUM, PSA	G185M 1913 A				200 Secs *[==>243.0 Secs]*	 ***[2]***
8		(1) POLARIS	COS/NUV, ACCUM, PSA	G185M 1941 A				200 Secs *[==>244.0 Secs]*	 ***[2]***
9		(1) POLARIS	COS/NUV, ACCUM, PSA	G185M 1882 A				200 Secs *[==>243.0 Secs]*	 ***[2]***


Orbit Structure
Orbit 1
Server Version: 20090130
GS Acq
Exp. 1
Exp. 2
Exp. 3
Exp. 4
Exp. 5
Occultation
Unused Visibility = 0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 2
Server Version: 20090130
GS Reacq
Exp. 6, split 1
Exp. 6, split 2
Exp. 6, split 3
Exp. 6, split 4
Exp. 7
Exp. 7 (Auto-WAVECAL)
Exp. 8
Exp. 8 (Auto-WAVECAL)
Exp. 9
Unused Visibility = 0
Occultation
Exp. 9 (Auto-WAVECAL)
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec