13369 - The Dynamical Mass of Polaris, the Nearest Cepheid

Cycle: 21, Proposal Category: GO

(UV Initiative)

(Availability Mode: AVAILABLE)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Nancy R. Evans (PI) (Contact)	**Smithsonian Institution Astrophysical Observatory**	**nevans@cfa.harvard.edu**
Dr. Howard E. Bond (CoI)	The Pennsylvania State University	heb11@psu.edu
Prof. Giuseppe Bono (CoI) (ESA Member)	Universita di Roma Tor Vergata	giuseppe.bono@roma2.infn.it
Dr. Margarita Karovska (CoI)	Smithsonian Institution Astrophysical Observatory	mkarovska@cfa.harvard.edu
Dr. Edmund Nelan (CoI)	Space Telescope Science Institute	nelan@stsci.edu
Dr. Kailash C. Sahu (CoI)	Space Telescope Science Institute	ksahu@stsci.edu
Dr. Gail Schaefer (CoI)	Georgia State University Research Foundation	schaefer@chara-array.org
Evan Tingle (CoI)	Smithsonian Institution Astrophysical Observatory	etingle@head.cfa.harvard.edu

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) POLARIS	WFC3/UVIS	1	06-Jun-2014 10:16:12.0	yes
03	(1) POLARIS	WFC3/UVIS	1	06-Jun-2014 10:16:14.0	yes
02	(3) GAMMA-CYG	WFC3/UVIS	1	06-Jun-2014 10:16:16.0	yes
04	(3) GAMMA-CYG	WFC3/UVIS	1	06-Jun-2014 10:16:17.0	yes

4 Total Orbits Used

ABSTRACT

Cepheid variables are the primary standard candles for measuring extragalactic distances, and they provide critical tests of stellar-evolution theory. Thus it is important to understand them astrophysically. Polaris (alpha UMi) is the nearest and brightest of all Cepheids. It offers a unique opportunity to measure the dynamical mass of a Cepheid, because it is in a 30-year binary system for which a single-lined spectroscopic orbit is already available. In Cycle 14, we resolved the system for the first time, using ACS/HRC in the UV, and followed up in Cycle 15. These observations established the sense of the orbital motion, as well as a first approximation to the dynamical mass. An observation with WFC3 in Cycle 17 again revealed the companion, in spite of the larger pixels than ACS/HRC, after deconvolution. This further refined our mass determination.

We propose an additional WFC3 observation in Cycle 21, which will extend the coverage of the orbit substantially. We estimate that this new observation will reduce the uncertainty in the mass of Polaris from 26% to 10%. The window for this observation is rapidly closing since the two stars are heading for periastron. This is a UV Initiative proposal since making the observations in the UV enhances the relative brightness of the companion, which is warmer than Polaris, by about 2 magnitudes relative to the visible. Because of the degradation of the PSF in short WFC3 exposures due to "shutter jitter," we also request one orbit to observe a nearby bright single star, Beta Cas, using identical exposure times, to serve as a PSF reference star in the specialized FQ232N filter that we will use.

OBSERVING DESCRIPTION

The aim of the observations is to resolve the very close, faint companion of Polaris, and measure its separation and position angle as part of a solution for the dynamical mass of Polaris. We will take a series of dithered 1.4-sec exposures on Polaris in the FQ232N filter, which makes unsaturated images of Polaris possible, and reduces the magnitude difference between the two stars. We will also take a set of identical exposures on Gamma Cas, in order to determine the PSF in this very rarely used WFC3 filter for a single star, observed with the same amount of shutter jitter as for Polaris. For all of the exposures, because of very faint backgrounds, we added FLASH=12.

Visit

Proposal 13369, Polaris (01), failed Fri Jun 06 14:16:18 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 322D TO 352 D; ORIENT 19.13D TO 26 D; BEFORE 15-JUN-2014:00:00:00

Comments: ORIENT is chosen to place the faint companion Polaris Ab at between "noon" and "1 o'clock" in the image frame relative to Polaris A, which appears to be the optimal location for the FQ232N PSF to avoid diffraction spikes and filter ghosts. A small window around "2 o'clock" is also allowed. The BEFORE 15-jun-2014 is included to assure that the observation is done in Cycle 21, so as to cover this important part of the binary orbit.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Polaris (01))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

(Exposure 2 (Polaris (01))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=true		(1)

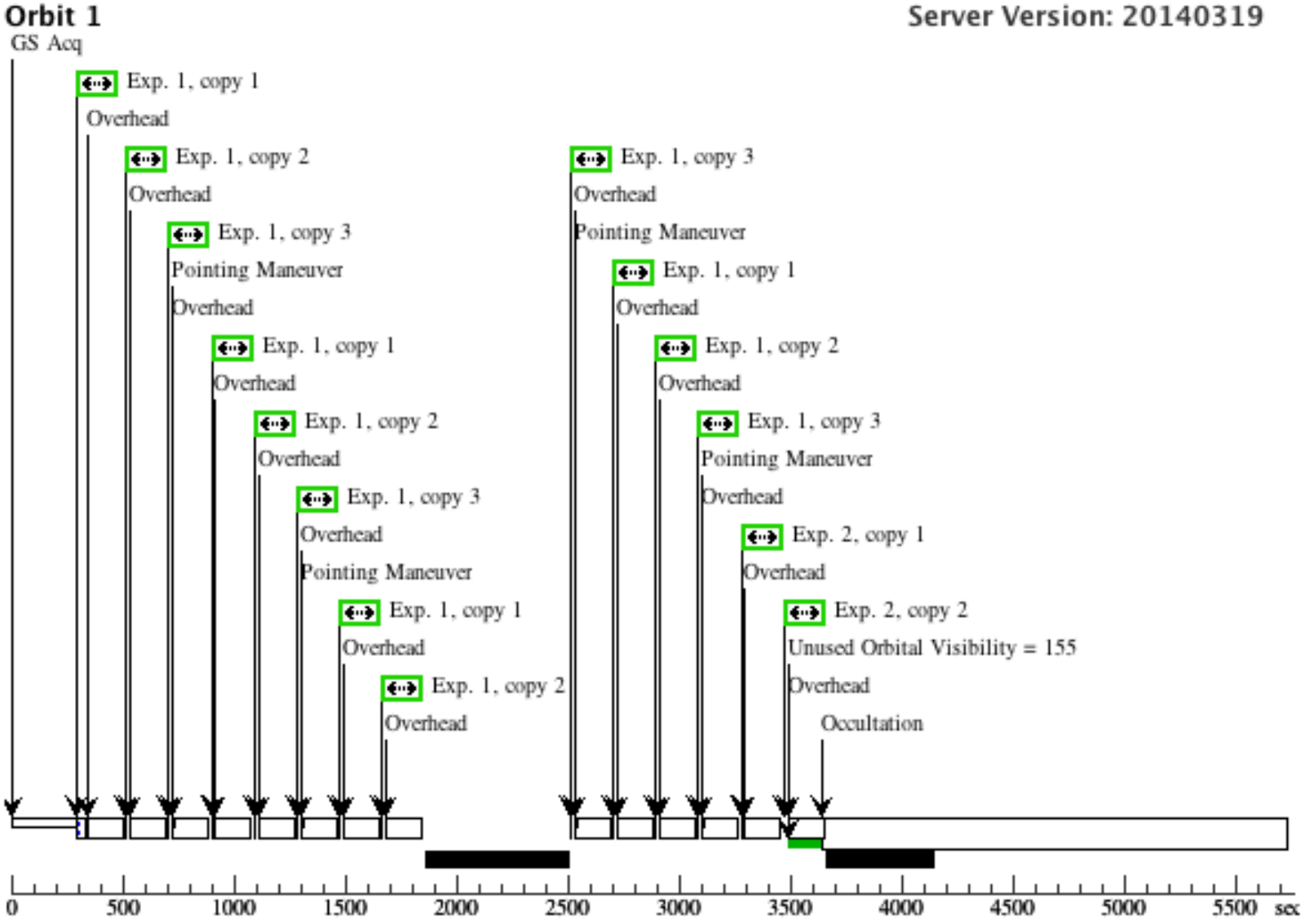
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POLARIS Alt Name1: ALPHA-UMI	RA: 02 31 49.0950 (37.9545625d) Dec: +89 15 50.79 (89.26411d) Equinox: J2000	Proper Motion RA: 44.48 mas/yr Proper Motion Dec: -11.85 mas/yr Parallax: 0.00754" Epoch of Position: 2000	V=1.98+/-0.1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) POLARIS	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO; FLASH=12; BLADE=A	GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-1 in Polaris (01) (1)	1.4 Secs X 3 (16.8 Secs)	
								[==>(Pattern 1, Copy 1)] *[==>(Pattern 1, Copy 2)]* *[==>(Pattern 1, Copy 3)]* *[==>(Pattern 2, Copy 1)]* *[==>(Pattern 2, Copy 2)]* *[==>(Pattern 2, Copy 3)]* *[==>(Pattern 3, Copy 1)]* *[==>(Pattern 3, Copy 2)]* *[==>(Pattern 3, Copy 3)]* *[==>(Pattern 4, Copy 1)]* *[==>(Pattern 4, Copy 2)]* *[==>(Pattern 4, Copy 3)]*	***[1]***
2		(1) POLARIS	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO; FLASH=12; BLADE=A	POS TARG 0,0		1.4 Secs X 2 (2.8 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]*	***[1]***

Orbit Structure



Visit

Proposal 13369, Polaris (03), implementation Fri Jun 06 14:16:18 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 300D TO 352 D; ORIENT 19.13D TO 26 D; ORIENT 142D TO 172 D; ORIENT 199.13D TO 206 D; BEFORE 15-JUL-2014:00:00:00

Comments: ORIENT is chosen to place the faint companion Polaris Ab at between "noon" and "1 o'clock" in the image frame relative to Polaris A, which appears to be the optimal location for the FQ232N PSF to avoid diffraction spikes and filter ghosts. A small window around "2 o'clock" is also allowed. The BEFORE 15-Oct-2014 is included to assure that the observation is done in Cycle 21, so as to cover this important part of the binary orbit.
Note that this is a repeat of Visit 01 which failed in March 2014. We also added orients differing by 180 deg from the originals, and changed the exposure times from 1.4 to 1.5 sec.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Sequence 1-2 Non-Int in Polaris (03))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

(Exposure 2 (Sequence 1-2 Non-Int in Polaris (03))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=true		(1)

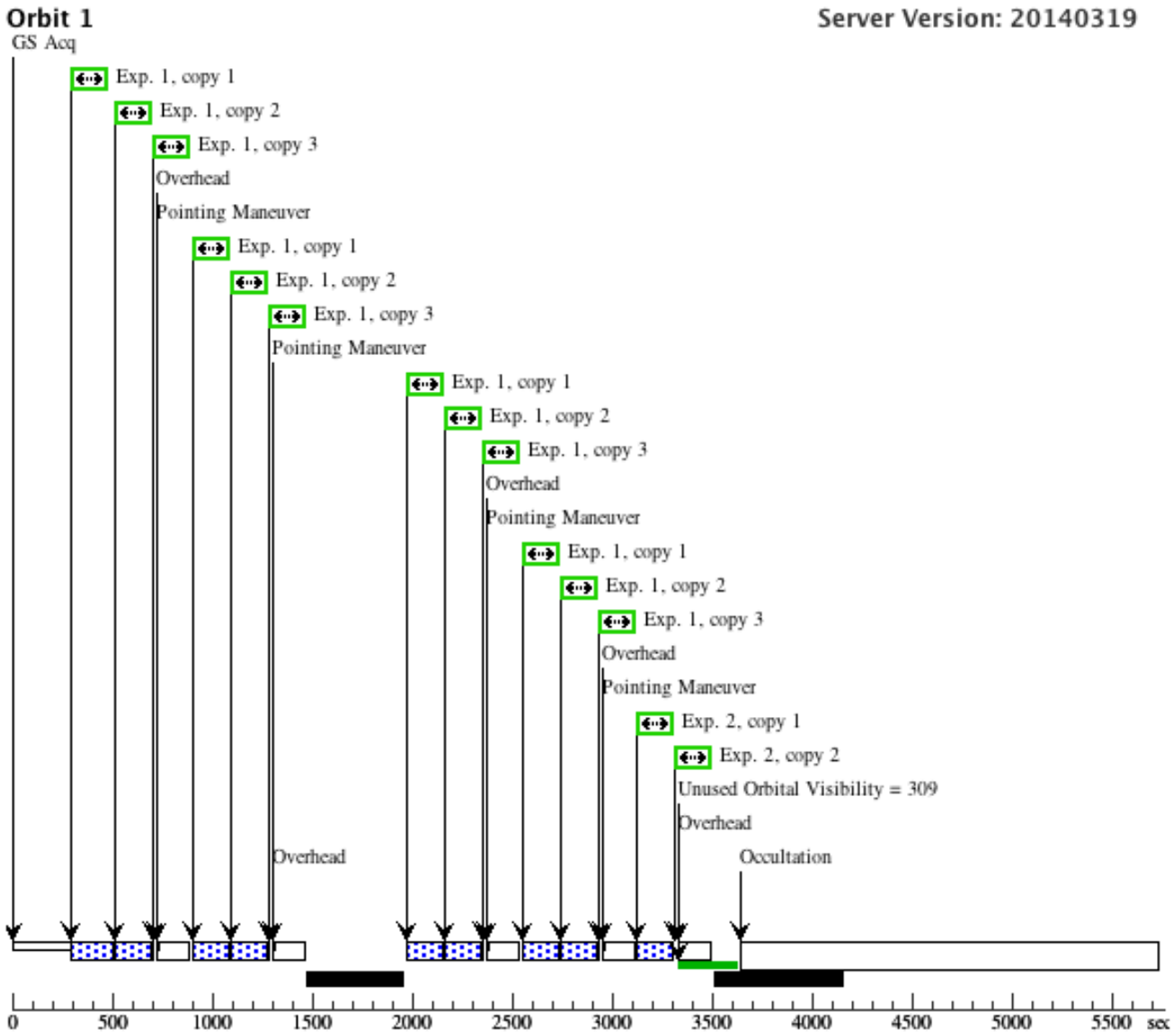
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POLARIS Alt Name1: ALPHA-UMI	RA: 02 31 49.0950 (37.9545625d) Dec: +89 15 50.79 (89.26411d) Equinox: J2000	Proper Motion RA: 44.48 mas/yr Proper Motion Dec: -11.85 mas/yr Parallax: 0.00754" Epoch of Position: 2000	V=1.98+/-0.1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) POLARIS	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO; FLASH=12; BLADE=A	GS ACQ SCENARIO BASE1B3	Sequence 1-2 Non-Int in Polaris (03) Pattern 1, Exps 1-1 in Sequence 1-2 Non-Int in Polaris (03) (1)	1.5 Secs X 3 (18 Secs) *[==>(Pattern 1, Copy 1)]* *[==>(Pattern 1, Copy 2)]* *[==>(Pattern 1, Copy 3)]* *[==>(Pattern 2, Copy 1)]* *[==>(Pattern 2, Copy 2)]* *[==>(Pattern 2, Copy 3)]* *[==>(Pattern 3, Copy 1)]* *[==>(Pattern 3, Copy 2)]* *[==>(Pattern 3, Copy 3)]* *[==>(Pattern 4, Copy 1)]* *[==>(Pattern 4, Copy 2)]* *[==>(Pattern 4, Copy 3)]*	***[1]***
2		(1) POLARIS	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO; FLASH=12; BLADE=A	POS TARG 0,0	Sequence 1-2 Non-Int in Polaris (03)	1.5 Secs X 2 (3 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]*	***[1]***

Orbit Structure



Visit

Proposal 13369, Gamma Cyg (02), failed Fri Jun 06 14:16:19 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: GROUP 02,01 WITHIN 2D

Comments: This is a PSF reference star for the analysis of the Polaris images. Set of exposures is identical to those for Polaris. Should be taken within a few HST orbits of the Polaris observation.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Gamma Cyg (02))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=true		(1)

Fixed Targets

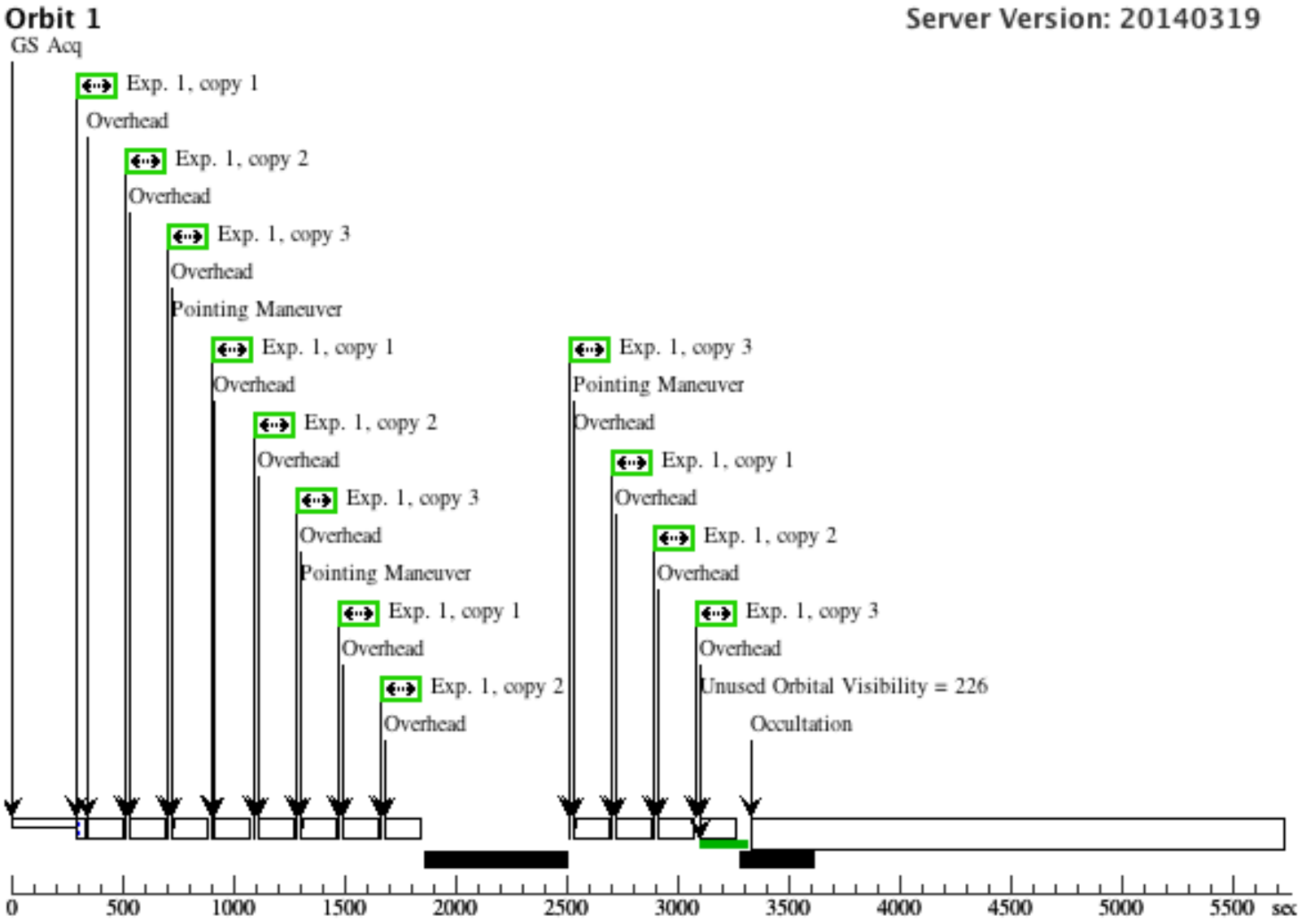
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	GAMMA-CYG	RA: 20 22 13.7018 (305.5570908d) Dec: +40 15 24.04 (40.25668d) Equinox: J2000	Proper Motion RA: 2.39 mas/yr Proper Motion Dec: -0.91 mas/yr Parallax: 0.00178" Epoch of Position: 2000	V=2.237	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(3) GAMMA-CYG	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO; FLASH=12; BLADE=A	GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-1 in Gamma Cyg (02) (1)	1.4 Secs X 3 (16.8 Secs) *[==>(Pattern 1, Copy 1)]* *[==>(Pattern 1, Copy 2)]* *[==>(Pattern 1, Copy 3)]* *[==>(Pattern 2, Copy 1)]* *[==>(Pattern 2, Copy 2)]* *[==>(Pattern 2, Copy 3)]* *[==>(Pattern 3, Copy 1)]* *[==>(Pattern 3, Copy 2)]* *[==>(Pattern 3, Copy 3)]* *[==>(Pattern 4, Copy 1)]* *[==>(Pattern 4, Copy 2)]* *[==>(Pattern 4, Copy 3)]*	***[1]***

Orbit Structure



Visit

Proposal 13369, Gamma Cyg (04), implementation Fri Jun 06 14:16:19 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: GROUP 04,03 WITHIN 2D

Comments: This is a PSF reference star for the analysis of the Polaris images. Set of exposures is identical to those for Polaris. Should be taken within a few HST orbits of the Polaris observation. Note that this is a repeat of Visit 02 which failed in March 2014.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Gamma Cyg (04))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=true		(1)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	GAMMA-CYG	RA: 20 22 13.7018 (305.5570908d) Dec: +40 15 24.04 (40.25668d) Equinox: J2000	Proper Motion RA: 2.39 mas/yr Proper Motion Dec: -0.91 mas/yr Parallax: 0.00178" Epoch of Position: 2000	V=2.237	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(3) GAMMA-CYG	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO; FLASH=12; BLADE=A	GS ACQ SCENARIO BASE1B3	Sequence 1-1 Non-Int in Gamma Cyg (04) Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Gamma Cyg (04) (1)	1.5 Secs X 3 (18 Secs) *[==>(Pattern 1, Copy 1)]* *[==>(Pattern 1, Copy 2)]* *[==>(Pattern 1, Copy 3)]* *[==>(Pattern 2, Copy 1)]* *[==>(Pattern 2, Copy 2)]* *[==>(Pattern 2, Copy 3)]* *[==>(Pattern 3, Copy 1)]* *[==>(Pattern 3, Copy 2)]* *[==>(Pattern 3, Copy 3)]* *[==>(Pattern 4, Copy 1)]* *[==>(Pattern 4, Copy 2)]* *[==>(Pattern 4, Copy 3)]*	***[1]***

Orbit Structure