10479 - The Distance and Mass of the Neutrino-Luminous White Dwarf PG 0122+200

Cycle: 14, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. M. Sean O'Brien (PI)	**Yale University**	**sean.obrien@yale.edu**
Dr. Howard E. Bond (CoI)	Space Telescope Science Institute	bond@stsci.edu
Dr. Edmund Nelan (CoI)	Space Telescope Science Institute	nelan@stsci.edu

VISITS

Visit	*Targets*	*Configurations*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(8) REF7 (7) REF6 (5) REF4 (6) REF5 (3) REF2 (1) PG0122+200 (4) REF3 (2) REF1	FGS	1	20-Jun-2005 11:51:45.0	yes

Visit	*Targets*	*Configurations*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
02	(8) REF7 (7) REF6 (5) REF4 (6) REF5 (3) REF2 (1) PG0122+200 (4) REF3 (2) REF1	FGS	1	20-Jun-2005 11:52:10.0	yes

2 Total Orbits Used

ABSTRACT

PG 0122+200 is a pulsating hot white dwarf that is believed to radiate more energy as neutrinos than it does as photons. We propose to measure with FGS the trigonometric parallax of PG 0122+200 and thereby determine its distance, luminosity, and mass. Ongoing investigations from the ground will infer the neutrino luminosity through its effect on the pulsation periods, thus testing standard and non-standard lepton theory, but the stellar mass must first be known. The pulsation spectrum of PG 0122+200 admits two alternative seismological interpretations, each implying a different mass, luminosity, and distance. Measurement of an accurate distance will resolve the matter once and for all and precisely determine the stellar mass. This project represents the first test of lepton physics in dense (log rho = 6) plasma and is relevant to the many areas of stellar physics in which neutrino interactions are important, including recent theories intended to solve the solar-neutrino problem.

OBSERVING DESCRIPTION

The proposed observations consist of astrometric measurements of PG 0122+200, along with about half a dozen reference stars surrounding it.

The target will be observed with FGS1R at five epochs of maximum parallax factor, i.e., at 6, 12, 18, and 24 months after the initial observation. At each epoch we will observe the target and its reference field during two HST visits separated by about two weeks. Each one-orbit visit will consist of

repeated measurements of our science target and the reference stars in the field of view. This will yield the relative positions of the stars for the visit and allow us to define the visit's "plate." The 24-month baseline will allow a robust determination of the proper motions of the targets, an essential ingredient in the parallax solution.

Once the observations from all 5 epochs have been completed, the observations will be combined with a "plate-overlay" technique to define a common reference frame (a "virtual plate") onto which the positions of the individual stars can be mapped. By comparing the position of the science target to the reference frame in the 10 independent observations obtained during the 5 epochs, we can solve for both the proper motion and the trigonometric parallax of the object, relative to the comparison stars.

Our request is thus for 10 orbits (5 visits 2 orbits per visit). This is a Long-Term proposal, since the observations must extend 24 months past the first visit. We request 4 orbits in Cycle 12, 4 in Cycle 13, and 2 in Cycle 14.

The derived FGS parallaxes will, of course, be relative to the reference frame of the fainter surrounding stars. In order to convert the relative parallax to absolute with the highest accuracy, we need an estimated parallax of each individual reference star. We therefore plan to obtain photometry and spectroscopy of each of the reference stars and determine spectroscopic parallaxes for them. We are applying herewith (see the Coordinated Observations section below) for the modest amount of NOAO observing time needed to obtain the data for the spectroscopic parallaxes of the reference stars.

FGS3, the original FGS used for HST astrometry, was capable of excellent parallax accuracy. For example, based on a series of FGS3 observations obtained in 1995-97, Benedict et al. (2002a,b) obtained absolute parallax accuracies of ?0.15 and ?0.20 mas for Cep and RR Lyr, respectively. For comparison, the Hipparcos accuracies for the same stars were ?0.58 and ?0.59 mas.

FGS1R, installed in 1997, has replaced FGS3 as the "astrometry" FGS. The performance of FGS1R should exceed that of FGS3 for two reasons. (1) FGS1R displays a temporal stability of its interferograms never achieved by FGS3, an attribute that greatly improves the measurement repeatability. (2) FGS1R benefits from a more robust calibration program. In particular, the observing technique employed to calibrate its geometric distortions (the dominant source of astrometric error) has resulted in residuals that are about 1/3 those of FGS3. The instrument's lateral color and cross-filter

calibrations are also better characterized.

Indications of FGS1R's excellent performance are becoming available. A recently completed program (McGrath et al. 2002) used FGS1R to search for the astrometric wobble of rho-1 Cnc due to its planetary companion. Fourteen orbits of FGS data were taken near one epoch of maximum parallax factor to search for the short-period wobble. To determine the proper motion and parallax, one additional orbit each was used 6 and 12 months later, so that the parallax error budget is essentially that of a 3-orbit program. Our team member Nelan, who is the STScI FGS Instrument Scientist, designed the observing strategy, and has done an unpublished analysis of the rho-1 Cnc parallax. The result shows a 1-sigma parallax error of ?0.4 mas.

We thus adopt ?0.4 mas as the error in an FGS1R parallax based on three one-orbit HST visits at 6-month intervals. This error can be reduced to ?0.4/(n/3)^1/2 mas, where n is the number of HST orbits, down to a systematic-error floor that we estimate to be < 0.15 mas. These considerations suggest that FGS1R should be able to measure the relative parallax of PG 0122+200 with an accuracy of at least 0.2 mas based on 10 HST orbits over the next three scheduling cycles.

Benedict, G.F. et al. 2002a, AJ, 123, 473
Benedict, G.F. et al. 2002b, AJ, 124, 1695
McGrath, M.A. et al. 2002, ApJ, 564, L27

Visit

Proposal 10479, Visit 01 Mon Jun 20 15:52:18 GMT 2005

Diagnostic Status: Warning

Scientific Instruments: FGS

Special Requirements: PCS MODE FINE; SCHED 30%; ORIENT 249.0D TO 255.0 D; BETWEEN 10-JUL-2005:00:00:00 AND 13-JUL-2005:00:00:00

Diagnostics

(Visit 01) Warning: GS ACQ SCENARIO REQUESTED INCONSISTENT WITH VISIT GYRO MODE

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PG0122+200 Alt Name1: BB Psc	RA: 01 25 22.4800 (21.3436667d) Dec: +20 17 56.94 (20.29915d) Equinox: J2000 Plate Id: 021K	Proper Motion RA: 0.0s/yr Proper Motion Dec: 0.0"/yr Parallax: 0.0" Epoch of Position:	V=16.3+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(2)	REF1 Alt Name1: GSC1204.01730	RA: 01 25 20.4800 (21.3353333d) Dec: +20 17 53.05 (20.29807d) Equinox: J2000 Plate Id: 021K		V=13.6+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(3)	REF2 Alt Name1: VTT-STAR	RA: 01 25 40.2000 (21.4175000d) Dec: +20 19 10.90 (20.31969d) Equinox: J2000 Plate Id: 021K		V=15.3+/-0.3	Coordinate Source: GUIDE_STAR_CATALOG
(4)	REF3 Alt Name1: GSC1204.01708	RA: 01 25 40.2000 (21.4175000d) Dec: +20 19 10.88 (20.31969d) Equinox: J2000 Plate Id: (?)		V=14.52+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(5)	REF4 Alt Name1: GSC1204.01610	RA: 01 25 51.0000 (21.4625000d) Dec: +20 19 59.16 (20.33310d) Equinox: J2000 Plate Id: (?)		V=13.42+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(6)	REF5 Alt Name1: GSC1204.01424	RA: 01 25 40.0100 (21.4167083d) Dec: +20 16 50.12 (20.28059d) Equinox: J2000 Plate Id: 021K		V=14.9+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(7)	REF6 Alt Name1: GSC1204.01790	RA: 01 25 32.1000 (21.3837500d) Dec: +20 16 24.02 (20.27334d) Equinox: J2000 Plate Id: 021K		V=14.22	Coordinate Source: GUIDE_STAR_CATALOG

Fixed Targets (continued)

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(8)	REF7 Alt Name1: GSC1204.01533	RA: 01 25 25.9500 (21.3581250d) Dec: +20 16 20.50 (20.27236d) Equinox: J2000 Plate Id: 021K		V=13.81+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG

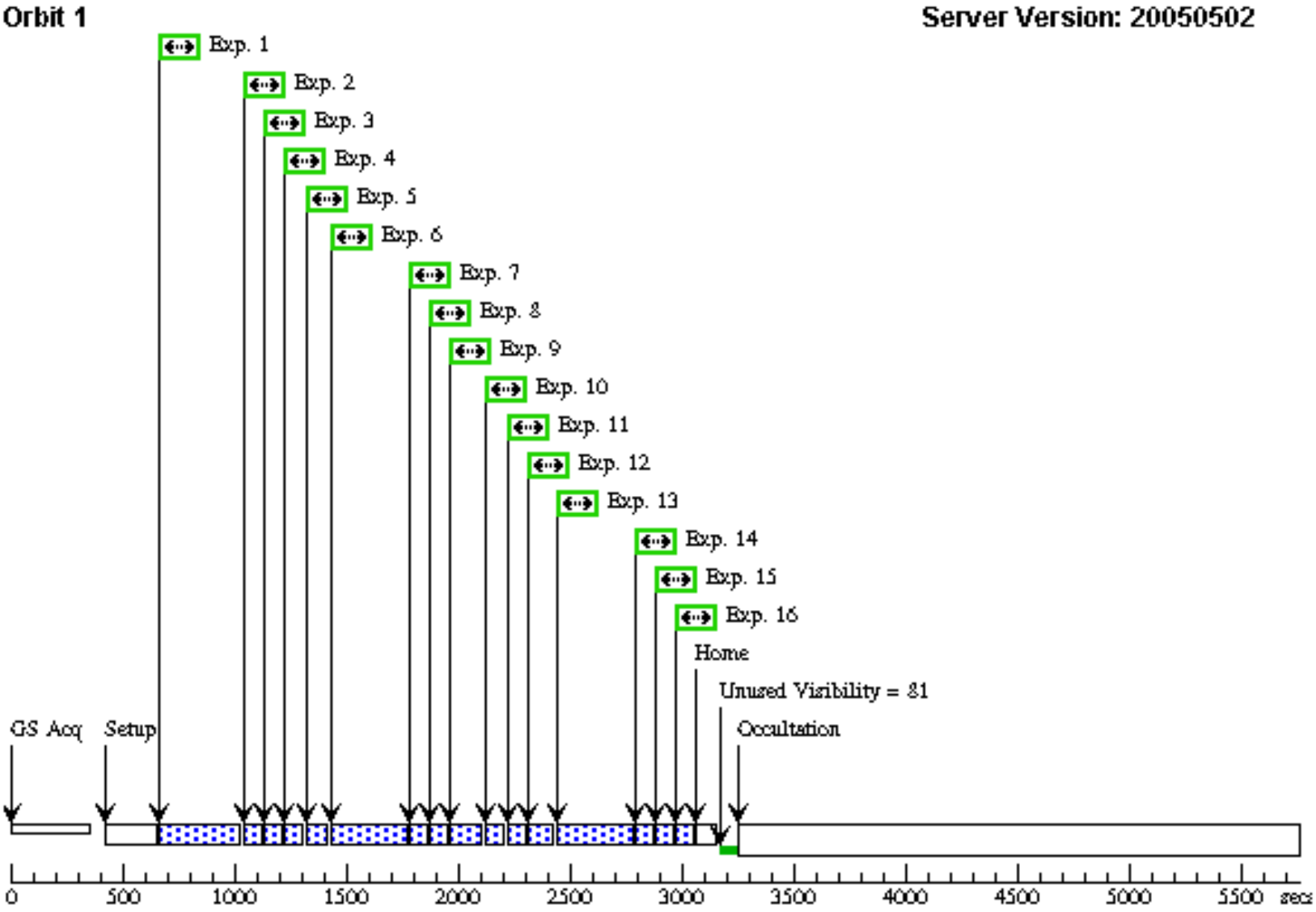
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) PG0122+200	FGS, POS, 1	F583W		POS TARG -99,-55; GSPAIR 0120301621F20120300898F3; GS ACQ SCENARIO BASE13GO	Sequence 1-16 Non-Int	45.0 Secs *[==>]*	 ***[1]***
2		(2) REF1	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
3		(8) REF7	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
4		(7) REF6	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
5		(6) REF5	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
6		(1) PG0122+200	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	45.0 Secs *[==>]*	 ***[1]***
7		(2) REF1	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
8		(8) REF7	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
9		(3) REF2	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
10		(4) REF3	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
11		(5) REF4	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
12		(6) REF5	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***

Exposures (continued)

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
13		(1) PG0122+200	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	45.0 Secs	
								[==>]	***[1]***
14		(2) REF1	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs	
								[==>]	***[1]***
15		(8) REF7	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs	
								[==>]	***[1]***
16		(7) REF6	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs	
								[==>]	***[1]***

Orbit Structure



Visit

Proposal 10479, Visit 02 Mon Jun 20 15:52:24 GMT 2005

Diagnostic Status: Warning

Scientific Instruments: FGS

Special Requirements: PCS MODE FINE; SCHED 30%; ORIENT 249.0D TO 255.0 D; AFTER 01 BY 1 D TO 3 D

Diagnostics

(Visit 02) Warning: GS ACQ SCENARIO REQUESTED INCONSISTENT WITH VISIT GYRO MODE

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PG0122+200 Alt Name1: BB Psc	RA: 01 25 22.4800 (21.3436667d) Dec: +20 17 56.94 (20.29915d) Equinox: J2000 Plate Id: 021K	Proper Motion RA: 0.0s/yr Proper Motion Dec: 0.0"/yr Parallax: 0.0" Epoch of Position:	V=16.3+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
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(4)	REF3 Alt Name1: GSC1204.01708	RA: 01 25 40.2000 (21.4175000d) Dec: +20 19 10.88 (20.31969d) Equinox: J2000 Plate Id: (?)		V=14.52+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(5)	REF4 Alt Name1: GSC1204.01610	RA: 01 25 51.0000 (21.4625000d) Dec: +20 19 59.16 (20.33310d) Equinox: J2000 Plate Id: (?)		V=13.42+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(6)	REF5 Alt Name1: GSC1204.01424	RA: 01 25 40.0100 (21.4167083d) Dec: +20 16 50.12 (20.28059d) Equinox: J2000 Plate Id: 021K		V=14.9+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG
(7)	REF6 Alt Name1: GSC1204.01790	RA: 01 25 32.1000 (21.3837500d) Dec: +20 16 24.02 (20.27334d) Equinox: J2000 Plate Id: 021K		V=14.22	Coordinate Source: GUIDE_STAR_CATALOG

Fixed Targets (continued)

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(8)	REF7 Alt Name1: GSC1204.01533	RA: 01 25 25.9500 (21.3581250d) Dec: +20 16 20.50 (20.27236d) Equinox: J2000 Plate Id: 021K		V=13.81+/-0.2	Coordinate Source: GUIDE_STAR_CATALOG

Exposures

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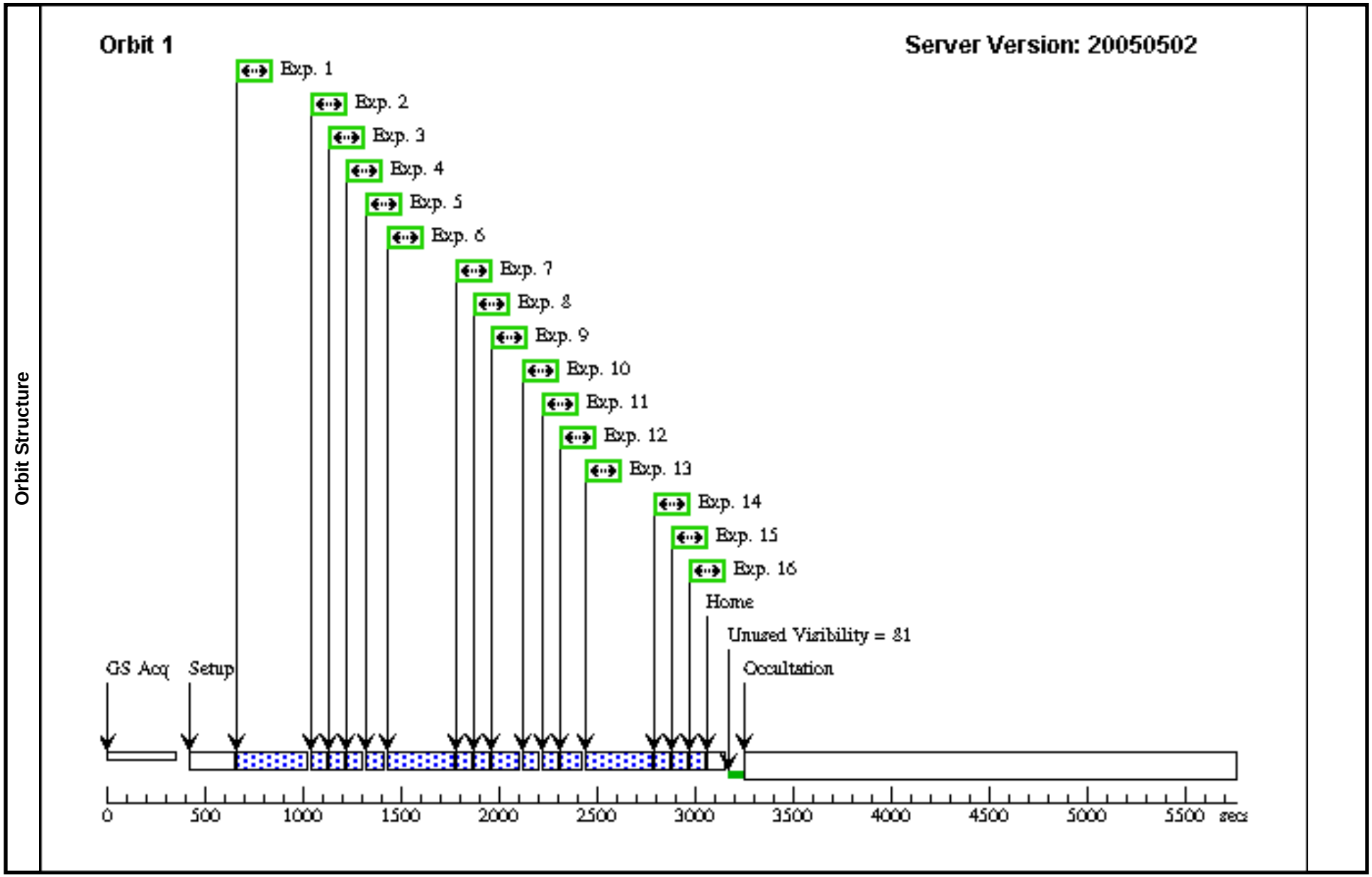
2		(2) REF1	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
3		(8) REF7	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
4		(7) REF6	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
5		(6) REF5	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
6		(1) PG0122+200	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	45.0 Secs *[==>]*	 ***[1]***
7		(2) REF1	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
8		(8) REF7	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
9		(3) REF2	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
10		(4) REF3	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
11		(5) REF4	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***
12		(6) REF5	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs *[==>]*	 ***[1]***

Exposures (continued)

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
13		(1) PG0122+200	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	45.0 Secs	
								[==>]	***[1]***
14		(2) REF1	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs	
								[==>]	***[1]***
15		(8) REF7	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs	
								[==>]	***[1]***
16		(7) REF6	FGS, POS, 1	F583W		SAME POS AS 1	Sequence 1-16 Non-Int	10.0 Secs	
								[==>]	***[1]***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Exp. 2
Exp. 3
Exp. 4
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Exp. 7
Exp. 8
Exp. 9
Exp. 10
Exp. 11
Exp. 12
Exp. 13
Exp. 14
Exp. 15
Exp. 16
Home
Unused Visibility = 81
GS Acq
Setup
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs