# 11786 - HST Observations of Astrophysically Important Visual Binaries

Cycle: 17, Proposal Category: GO

(Availability Mode: SUPPORTED)

**INVESTIGATORS**



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**VISITS**

| *Visit* | *Targets used in Visit* | *Configurations used in Visit* | *Orbits Used* | *Last Orbit Planner Run* | *OP Current with Visit?* |
|---|---|---|---|---|---|
| 01 | (1) PROCYON | WFC3/UVIS | 1 | 27-Jul-2009 21:50:16.0 | yes |
| 02 | (2) MU-CAS | WFC3/UVIS | 1 | 27-Jul-2009 21:50:30.0 | yes |

| *Visit* | *Targets used in Visit* | *Configurations used in Visit* | *Orbits Used* | *Last Orbit Planner Run* | *OP Current with Visit?* |
|---|---|---|---|---|---|
| 03 | (3) G107-70<br>(4) G107-69<br>(5) G107-70-REF2<br>(6) G107-70-REF3<br>(7) G107-70-REF4<br>(8) G107-70-REF6<br>(9) G107-70-REF7<br>(10) G107-70-REF9 | FGS | 1 | 27-Jul-2009 21:50:39.0 | yes |

3 Total Orbits Used

**ABSTRACT**

This is a continuation of a project begun in Cycle 7 and continued up through Cycle 14. The program consists of annual FGS or WFPC2 observations of three visual binary stars that will yield fundamental astrophysical results, once their orbits and masses are determined. In Cycle 17 we are changing WFPC2 to WFC3.

Our targets are the following: (1) Procyon (P = 40.9 yr), for which our first WFPC2 images yielded an extremely accurate angular separation of the bright F star and its much fainter white-dwarf companion. Combined with ground-based astrometry of the bright star, our observation significantly revised downward the derived masses, and brought Procyon A into much better agreement with theoretical evolutionary masses for the first time. With the continued monitoring proposed here, we will obtain masses to an accuracy of better than 1%, providing a testbed for theories of both Sun-like stars and white dwarfs. (2) G 107-70, a close double white dwarf (P = 18.5 yr) that promises to add two accurate masses to the tiny handful of white-dwarf masses that are directly known from dynamical measurements. (3) Mu Cas (P = 20.8 yr), a famous nearby metal-deficient G dwarf for which accurate masses will lead to the stars' helium contents, with cosmological implications. For all three stars, we will also be setting increasingly stringent limits on the presence of planetary-mass bodies in the systems.

**OBSERVING DESCRIPTION**

This is the Cycle 17 continuation of a 3-cycle program in which we are determining the orbits of three visual binaries. The targets are Procyon, mu Cas, and G 107-70.

We have been observing G 107-70 with FGS, and this part of the program will continue as before, with 1 orbit of POS mode observations of the target and reference stars.

We had been observing Procyon and mu Cas with WFPC2. Following SM4, we are changing to WFC3/UVIS. For Procyon we will use the long-wavelength F953N filter to reduce its signal. Since even with this filter Procyon A will saturate in the minimum WFC3 exposure, we will let it saturate and use the diffraction spikes to centroid Procyon A. These exposures will be 12 sec. We will alternate these with 36-sec exposures, which will provide good unsaturated exposures for Procyon B at the same telescope pointing. For mu Cas, we will use 1-sec exposures in F225W, which the WFC3 ETC predicts will not saturate. These will be followed at each dither position with a 260-sec exposure, which will be well exposed for the cool dM companion.

## Visit

**Proposal 11786, Visit 01, implementation** Tue Jul 28 01:50:44 GMT 2009

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 223.8D TO 300.2 D; ORIENT 313.8D TO 341 D; ORIENT 3D TO 30.2 D; ORIENT 43.8D TO 120.2 D; BETWEEN 01-SEP-2009:00:00:00 AND 01-MAR-2010:00:00:00

*Comments: ORIENT requirement is done so that companion star will not lie near diffraction spikes or charge bleeding from the very bright primary star.*

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=WFC3-UVIS-DITHER-BOX<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.173<br>Line Spacing=0.112 | Coordinate Frame=POS-TARG<br>Pattern Orientation=23.884<br>Angle Between Sides=81.785<br>Center Pattern=true | | (1-2), (3-4) |

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | PROCYON | RA: 07 39 18.3700 (114.8265417d) | Proper Motion RA: -0.04755s/yr | V=0.36+/-0.0 | Reference Frame: ICRS |
| | Alt Name1: ALPHA-CMI | Dec: +05 13 35.50 (5.22653d) | Proper Motion Dec: -1.0229"/yr | B-V = 0.42 | |
| | Alt Name2: HR2943 | Equinox: J2000 | Parallax: 0.283" | | |
| | | | Epoch of Position: 1995.18 | | |

*Comments: Coords are for center of gravity of binary. Accuracy confirmed by 2000 Nov 28 WFPC2 observations. 6/14/06: updated to ICRS system using galex website.*

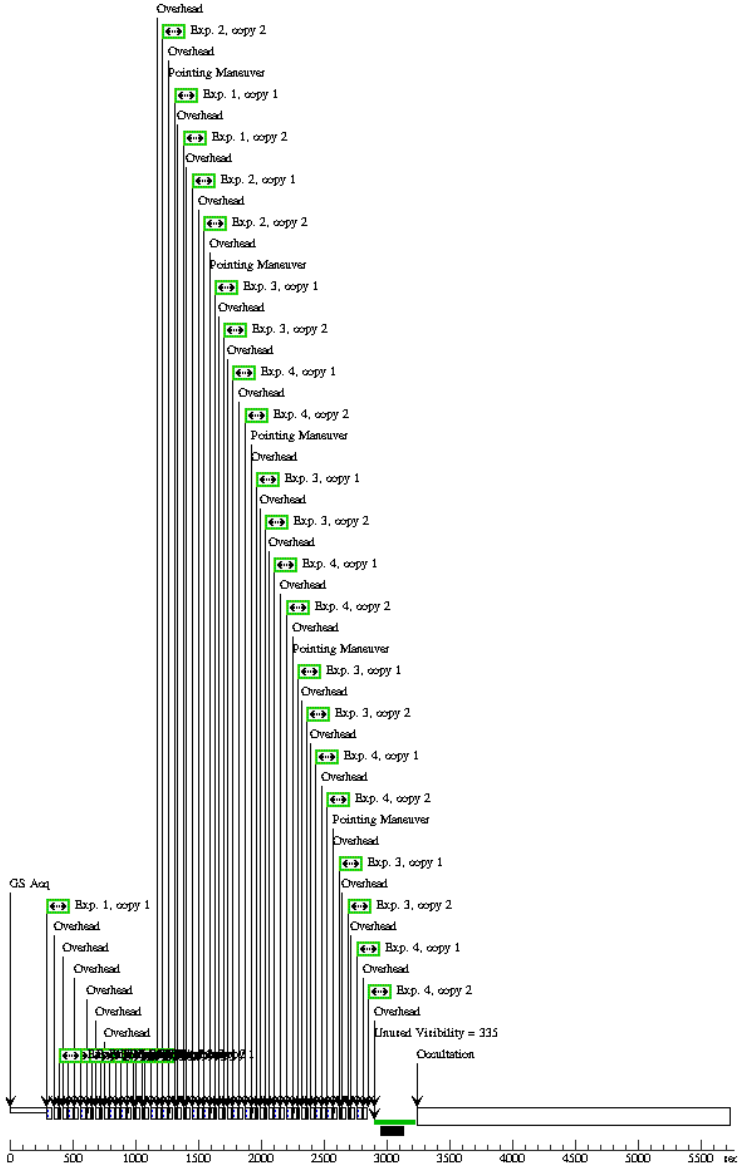
## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (1) PROCYON | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F953N | CR-SPLIT=NO | | Pattern 1, Exps 1-2 ( 1) | 12 Secs X 2 | |
| | | | | | | | | *[==>(Pattern 1, Copy 1)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 1, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 2)]* | |
| 2 | | (1) PROCYON | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F953N | CR-SPLIT=NO | | Pattern 1, Exps 1-2 ( 1) | 36 Secs X 2 | |
| | | | | | | | | *[==>(Pattern 1, Copy 1)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 1, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 2)]* | |

**Exposures (continued)**

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 3 | | (1) PROCYON | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F953N | CR-SPLIT=NO | | Pattern 1, Exps 3-4 ( 1) | 12 Secs X 2 | |
| | | | | | | | | *[==>(Pattern 1, Copy 1)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 1, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 2)]* | |
| 4 | | (1) PROCYON | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F953N | CR-SPLIT=NO | | Pattern 1, Exps 3-4 ( 1) | 36 Secs X 2 | |
| | | | | | | | | *[==>(Pattern 1, Copy 1)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 1, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 2, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 3, Copy 2)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 1)]* | |
| | | | | | | | | *[==>(Pattern 4, Copy 2)]* | |

**Orbit Structure**



## Visit

**Proposal 11786, Visit 02, implementation** Tue Jul 28 01:50:45 GMT 2009

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/UVIS

Special Requirements: SCHED 50%; ORIENT 67.8D TO 124.2 D; ORIENT 157.8D TO 165 D; ORIENT 207D TO 214.2 D; ORIENT 247.8D TO 304.2 D; ORIENT 27D TO 34.2 D; BETWEEN 01-SEP-2009:00:00:00 AND 01-MAR-2010:00:00:00

*Comments: ORIENT requirement is done so that companion star will not lie near diffraction spikes or charge bleeding of primary star.*

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=WFC3-UVIS-DITHER-BOX<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.173<br>Line Spacing=0.112 | Coordinate Frame=POS-TARG<br>Pattern Orientation=23.884<br>Angle Between Sides=81.785<br>Center Pattern=true | | (1-2), (3-4) |

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (2) | MU-CAS<br>Alt Name1: HR321<br>Alt Name2: HD6582 | RA: 01 08 16.3700 (17.0682083d)<br>Dec: +54 55 13.20 (54.92033d)<br>Equinox: J2000 | Proper Motion RA: 0.3972s/yr<br>Proper Motion Dec: -1.596"/yr<br>Parallax: 0.134"<br>Epoch of Position: 2000.0 | V=5.15+/-0.0<br>B-V = 0.70 | Reference Frame: ICRS |

*Comments: Coordinate accuracy confirmed by 2000-01 WFPC2 observations. 6/14/06: updated to ICRS system using galex website.*

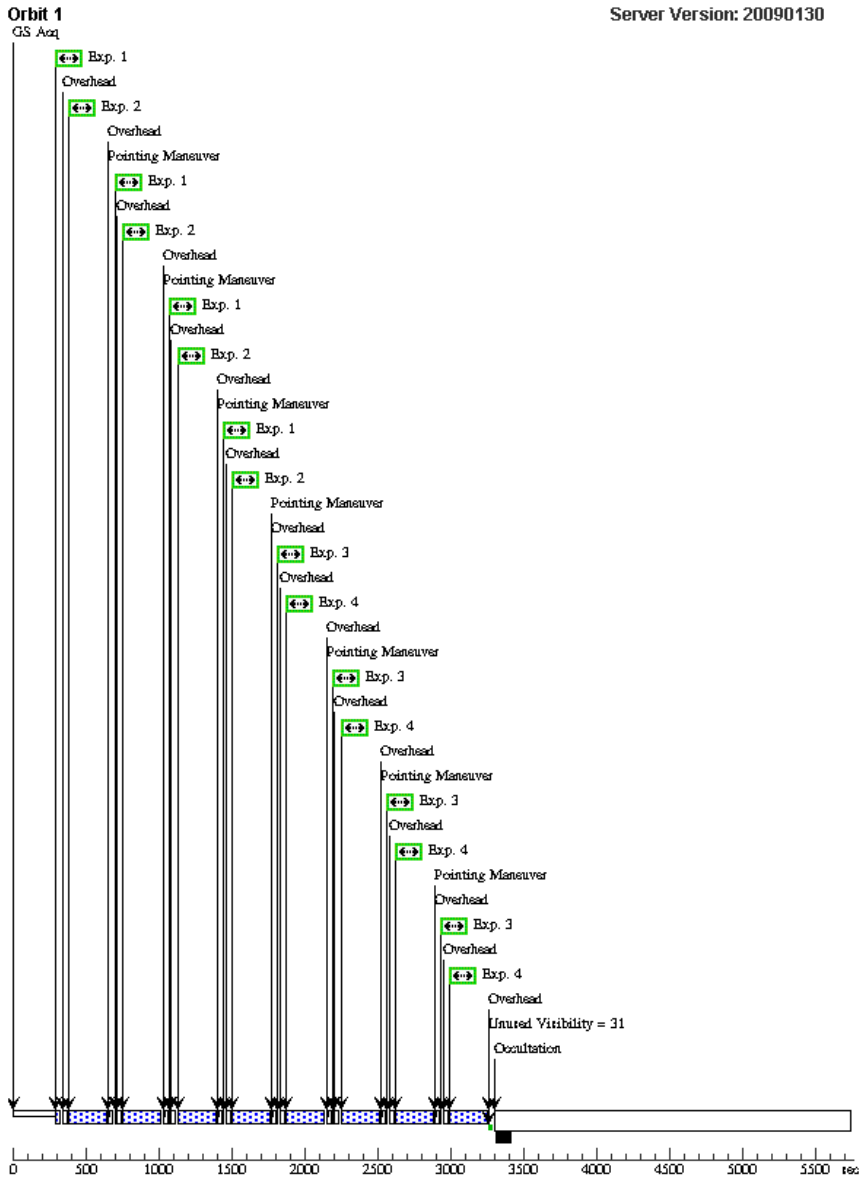
## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (2) MU-CAS | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F225W | CR-SPLIT=NO | | Pattern 1, Exps 1-2 ( 1) | 1 Secs | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | ***[1]*** |
| 2 | | (2) MU-CAS | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F225W | CR-SPLIT=NO | | Pattern 1, Exps 1-2 ( 1) | 260 Secs | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | ***[1]*** |
| 3 | | (2) MU-CAS | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F225W | CR-SPLIT=NO | | Pattern 1, Exps 3-4 ( 1) | 1 Secs | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | ***[1]*** |

**Exposures (continued)**

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 4 | | (2) MU-CAS | WFC3/UVIS, ACCUM, UVIS1-M512-SUB | F225W | CR-SPLIT=NO | | Pattern 1, Exps 3-4 ( 1) | 260 Secs | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | ***[1]*** |

**Orbit Structure**



## Visit

**Proposal 11786, Visit 03, implementation** Tue Jul 28 01:50:46 GMT 2009

**Diagnostic Status: No Diagnostics**

Scientific Instruments: FGS

Special Requirements: ORIENT 110.D TO 110.0 D; BETWEEN 28-MAR-2010:00:00:00 AND 07-APR-2010:00:00:00

*Comments: Maximum parallax factors April 10, October 11. This ORIENT can schedule up to April 6, and results in a favorable projection of the G107-70 components (PA ~ 189 degrees) in the FGS frame.*

## Fixed Targets

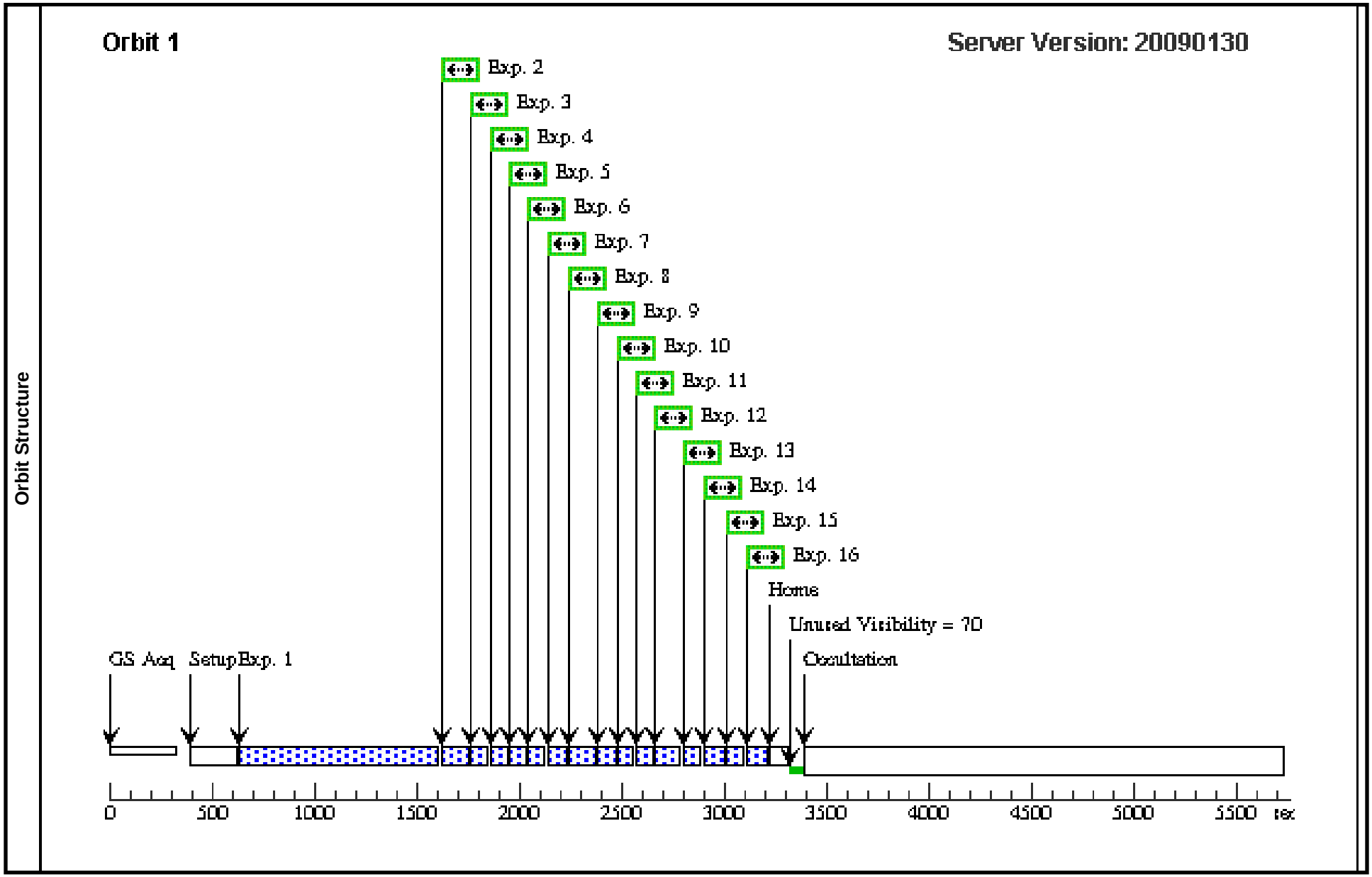
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (3) | G107-70 | RA: 07 30 47.2300 (112.6967917d)<br>Dec: +48 10 26.60 (48.17406d)<br>Equinox: J2000 | Proper Motion RA: -0.022s/yr<br>Proper Motion Dec: -1.271"/yr<br>Parallax: 0.09"<br>Epoch of Position: 2000.0 | V=15.5+/-0.1 | Reference Frame: ICRS |
| *Comments: double degenerate binary system, separation ~0.6"* | | | | | |
| (4) | G107-69 | RA: 07 30 42.5700 (112.6773750d)<br>Dec: +48 11 58.80 (48.19967d)<br>Equinox: J2000 | Proper Motion RA: -0.022s/yr<br>Proper Motion Dec: -1.272"/yr<br>Parallax: 0.09"<br>Epoch of Position: 2000 | V=13.6+/-0.1 | Reference Frame: ICRS |
| *Comments: CPM companion to G107-70, ~1 arcmin distant* | | | | | |
| (5) | G107-70-REF2 | RA: 07 30 26.6900 (112.6112083d)<br>Dec: +48 11 1.64 (48.18379d)<br>Equinox: J2000 | | V=13.3+/-0.1 | Reference Frame: ICRS |
| (6) | G107-70-REF3 | RA: 07 31 9.7700 (112.7907083d)<br>Dec: +48 10 27.41 (48.17428d)<br>Equinox: J2000 | | V=14.3+/-0.1 | Reference Frame: ICRS |
| (7) | G107-70-REF4 | RA: 07 30 57.1700 (112.7382083d)<br>Dec: +48 08 36.71 (48.14353d)<br>Equinox: J2000 | | V=12.2+/-0.1 | Reference Frame: ICRS |
| (8) | G107-70-REF6 | RA: 07 30 34.9200 (112.6455000d)<br>Dec: +48 10 31.22 (48.17534d)<br>Equinox: J2000 | | V=14.3+/-0.1 | Reference Frame: ICRS |
| (9) | G107-70-REF7 | RA: 07 31 0.3100 (112.7512917d)<br>Dec: +48 10 16.07 (48.17113d)<br>Equinox: J2000 | | V=14.9 | Reference Frame: ICRS |
| (10) | G107-70-REF9 | RA: 07 30 15.0300 (112.5626250d)<br>Dec: +48 10 19.67 (48.17213d)<br>Equinox: J2000 | | V=12.9 | Reference Frame: ICRS |

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (3) G107-70 | FGS, TRANS, 1 | F583W | SCANS=12;<br>STEP-SIZE=0.8 | POS TARG 0.0,-30.0;<br>GS ACQ SCENARIO BASE1B3 | Sequence 1-16 Non-Int | 715.0 Secs<br>*[==>]* | <br>***[1]*** |

**Exposures (continued)**

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 2 | | (3) G107-70 | FGS, POS, 1 | F583W | FES-TIME=0.4 | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 3 | | (4) G107-69 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 4 | | (10) G107-70-REF9 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 5 | | (7) G107-70-REF4 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 6 | | (6) G107-70-REF3 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 7 | | (4) G107-69 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 8 | | (3) G107-70 | FGS, POS, 1 | F583W | FES-TIME=0.4 | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 9 | | (8) G107-70-REF6 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 10 | | (5) G107-70-REF2 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 11 | | (7) G107-70-REF4 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 12 | | (3) G107-70 | FGS, POS, 1 | F583W | FES-TIME=0.4 | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 13 | | (4) G107-69 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 14 | | (9) G107-70-REF7 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 15 | | (6) G107-70-REF3 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 16 | | (10) G107-70-REF9 | FGS, POS, 1 | F583W | | SAME POS AS 1 | Sequence 1-16 Non-Int | 7 Secs | |
| | | | | | | | | *[==>]* | ***[1]*** |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Orbit Structure
Exp. 2
Exp. 3
Exp. 4
Exp. 5
Exp. 6
Exp. 7
Exp. 8
Exp. 9
Exp. 10
Exp. 11
Exp. 12
Exp. 13
Exp. 14
Exp. 15
Exp. 16
Home
Unused Visibility = 70
GS Acq
Setup
Exp. 1
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec