# 12667 - Kinematic Reconstruction of the Origin and IMF of the Massive Young Clusters at the Galactic Center

Cycle: 19, Proposal Category: GO

(Availability Mode: SUPPORTED)

**INVESTIGATORS**



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|---|---|---|
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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) ARCHES | WFC3/IR | 3 | 15-May-2012 21:23:29.0 | yes |
| 02 | (2) QUINTUPLET | WFC3/IR | 3 | 15-May-2012 21:24:03.0 | yes |
| 03 | (3) SGRA | WFC3/IR | 3 | 15-May-2012 21:24:35.0 | yes |

9 Total Orbits Used

**ABSTRACT**

We propose to exploit the wide field capabilities of Wide Field Camera 3 to study star formation at the Galactic center. By studying young stars located in the most physically extreme region of our Galaxy, we can test star formation theories, which suggest that such environments should favor high mass stars and, in extreme cases, should suppress star formation entirely. Specifically, we will measure the proper motions and photometry of stars over the full extent of the three massive young clusters that have been identified at the Galactic Center (Arches, Quintuplet, and the Young Nuclear Star Cluster). These observations are a factor of 2000 more efficient than what can be done with ground-based adaptive optics. Our goals are two-fold. First, we hope to establish the initial sites of star formation in order to obtain an accurate estimate of the conditions that led to the stellar populations within these clusters. Answering this question for the Young Nuclear Star Cluster is particularly important as it establishes whether or not star formation can indeed proceed within 0.1 pc of our Galaxy's supermassive black hole. Second, we will measure the IMF in the Arches and Quintuplet, where dynamical evolution is less severe, using proper motions to determine membership and to reveal the tidal radius. Probing how the properties of the emergent stellar populations within our Galaxy may be affected by the physical environment in which they arise is an important first step to understanding how they might vary as a function of cosmic time and thereby affect our models of galaxy formation and evolution.

**OBSERVING DESCRIPTION**

Update May 2012 -- Checking jitter files from Cycle 18 observations, guide stars have been checked to ensure the same guide stars are requested in Cycle 19 for all targets as were used in Cycle 18. This resulted in no change to the guide stars requested for Visit01 and Visit03; however for Visit02 the guide star pair has been changed; see the Visit-level pane for Visit02.

Update June 2011 -- This project consists of observations in three cycles; photometry and astrometry in cycle 17, astrometry in cycles 18 and 19. The observations for cycles 18 and 19 are clones of the astrometry observations in cycle 17 (updated for SgrA* to improve the dithering). Cycle 18 (GO-12318) was updated recently to reproduce HST's roll angle from cycle 17 as closely as possible. To repeat the observations as closely as possible, this phase II is a clone of the cycle 18 observations. Information on specific roll angles and guide stars can be found below in this Observing Description.

Update June 2011 -- 3-band photometry was completed in cycle 17. Cycle 18 observations are for astrometry only in filter F153M. For these cycle 18 datasets, we require the same ORIENT for each target as in the cycle 17 visits to the same target. The commanded roll angles for HST for the cycle 17 observations were: Arches: 90 degrees; SgrA: 90 degrees; Quintuplet: 93 degrees. These numbers are based on header keywords (ORIENTAT -

BETA_2 + 180.0), as recommended by STScI's orient FAQ: http://www.stsci.edu/hst/observatory/faqs/orient.faq

Update June 2011 - II: We also request that the targets be observed with the same guide stars for the most accurate astrometry:
TARGET DGESTAR SGESTAR
Arches S8DO000001F1 S8DO000018F2
Quintuplet S8DM000071F1 S8DO062365F2
SgrA S8DM043317F1 S8DO060030F2

Update July 2010 -- based on experience with visit03 of 11671, which was observed about 2 weeks before the phase II deadline for cycle 18, we have rotated the spiral dither patterns slightly to afford better phase coverage. We have also added two short exposures to fill unused visibility at the end of the final orbit in each visit, using the 512x512 subarray and RAPID read mode to afford much better coverage for saturated objects (in the central region) than can be achieved with any of the full-frame readout modes.

Update July 2010 -- For these cycle 18 datasets, we require the same ORIENT for each target as in the cycle 17 visits to the same target. At the time of submission of this phase II, the SgrA* visits from cycle 17 have already taken place so we restrict our roll angle ranges to the same angle as previously observed. For the other two targets (Arches and Quintuplet; visits 01, 02) we provide the ORIENT range corresponding to the program windows we expect for those targets in cycle 17. We intend to supply more precise constraints once the cycle 17 observations for the arches and quintuplet take place during august/september 2010.

Update August 2009 - ORIENT ranges specified. We need to observe at the same U3 angle in subsequent cycles, so we have selected the ORIENT values that give the broadest possible schedule windows (according to APT).

Our experiments on the Arches, Quintuplet, and the Young Nuclear Star Cluster will be conducted with both astrometric and three-filter photometric measurements. The Galactic Center is optically obscured and the three clusters have a large (~100”) predicted spatial extent; therefore, all observations will be conducted with WFC3 in the near infrared. The specific requirements and exposure times for the astrometry and photometry are described below. Our group has significant experience in working with high precision astrometric and photometric data sets both in general and from HST.

Astrometry:

To achieve the required 1 mas astrometric precision with WFC3, it is important that the orientation and positioning of the fields of view are the same for our observations in all three HST cycles (17, 18, and 19). Additionally, we will improve the PSF sampling by using a spiral dither pattern that has sub-pixel steps. The total extent of the dither pattern is less than 20 pixels. These requirements are all necessary to reduce the effects of optical distortion; however, to achieve the most accurate astrometry, we must have a high quality optical distortion solution for the camera. Our science requires a distortion solution that yields residuals of <0.01 pixels (1 mas) in WFC3-IR. Members of our group have shown that this level of distortion correction is possible for under-sampled PSFs such as in WFC3. Distortion calibration to 0.005 pixels has been achieved with ACS and is also planned for WFC3 using similar techniques. To minimize the impact of any residual distortions, we request that the astrometric observations within each cluster have the SAME ORIENT with small POS TARG offsets in all three cycles.

Our observations should reach at least a SNR ~100 for an H=20 star. Individual exposure times are limited by the effects of persistence from saturated sources, which can negatively impact astrometry and photometry. We chose a medium band filter for our astrometry rather than a wide filter in order to avoid saturating the brightest sources in the field (H=10) prior to the first detector read. Some saturated sources are inevitable since the brightest sources are H=10 in the Quintuplet and H=12 in the Arches. These sources will saturate in less than 3 s; however, the density of bright stars is low enough that hard-saturating all stars with H<15 (<100 stars in the 120” field of view) should produce persistence images with a low enough density that dithering can shift sources in subsequent exposures on to persistence-free portions of the detector. Saturated sources will be recoverable from the earliest reads of the up-the-ramp samples used by WFC3. The maximum possible exposure time to avoid persistence images from stars fainter than H=15 is ~350 s. Therefore, our H-band astrometric program will consist of a series of exposures with texp =349.2 to accommodate 12 MULTIACCUM readouts (STEP 50 readout pattern).

Photometry:
Photometry will be extracted from three medium band filters: F153M, F139M, and F127M to accurately construct extinction maps for all three clusters and mass functions for the Arches and Quintuplet. These measurements require reaching a SNR of ~35 at m_F139M ~ 21.5 and m_F127M ~ 23. Saturation considerations are similar to those described above and the optimal exposure times for the two filters are t_{exp,F139M} = 349 s and t_{exp,F127M} =600 s. Again to maximize sampling of the PSF, we choose sub-pixel steps for the dither patterns.

**REAL TIME JUSTIFICATION**
In order to achieve the necessary astrometric precision, we need observations in cycle 17, 18, and 19 to be observed at the same roll angle and with the same guide stars.

## Visit

**Proposal 12667, Visit 01, implementation** Wed May 16 01:24:45 GMT 2012

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 90.00D TO 90.00 D

*Comments: Arches F153M Astrometry.*
*These cycle 19 observations should be taken at the exact same orientation and with the same guide stars as our cycle 17/18 observations of this target (from Cycle 17 Arches jitterfiles):*

*TARGET DGESTAR SGESTAR*
*Arches S8DO000001F1 S8DO000018F2*

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (2) | Pattern Type=SPIRAL | Coordinate Frame=POS-TARG | | (1) |
| | Purpose=DITHER | Pattern Orientation=11.0 | | |
| | Number Of Points=21 | Angle Between Sides= | | |
| | Point Spacing=0.42 | Center Pattern=false | | |
| | Line Spacing= | | | |

## Fixed Targets

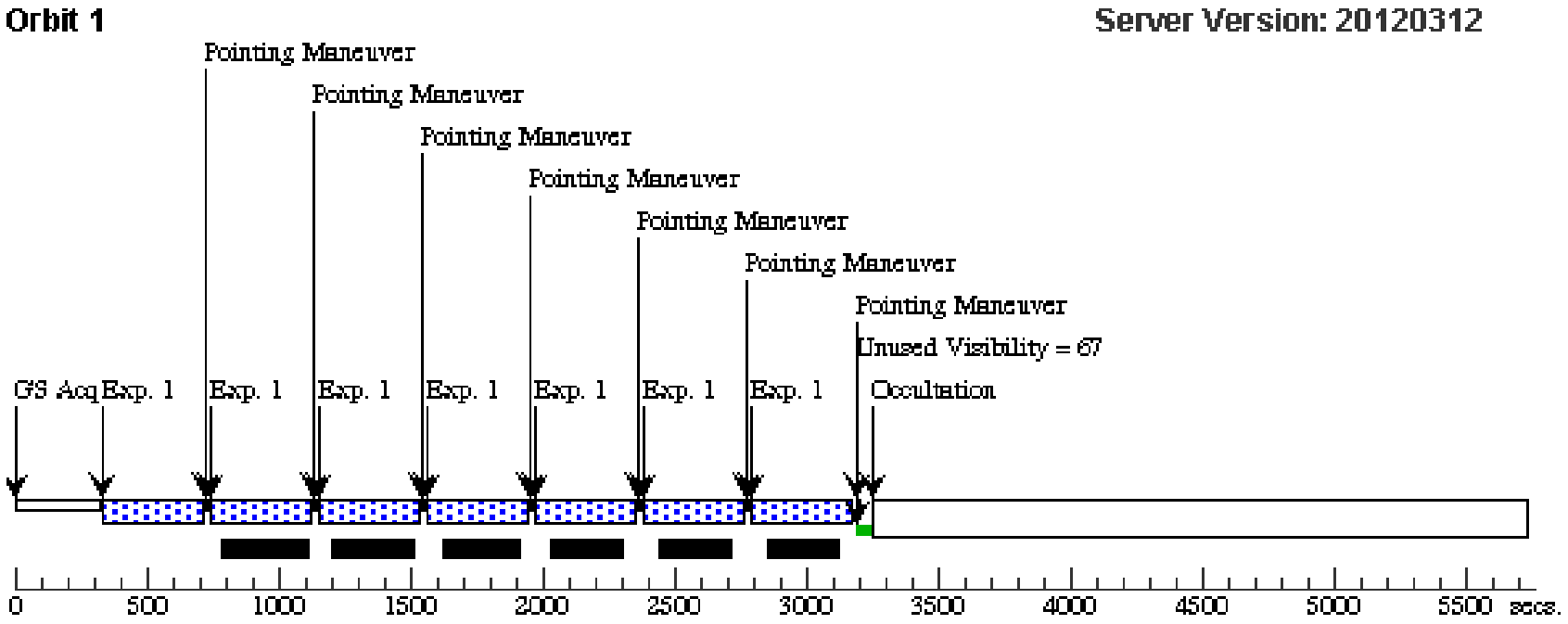
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | ARCHES | RA: 17 45 50.5000 (266.4604167d) | | V=16.5+/-0.1 | Reference Frame: ICRS |
| | | Dec: -28 49 20.00 (-28.82222d) | | J=11.5, | |
| | | Equinox: J2000 | | H=10.5, | |
| | | | | K=10.2 | |

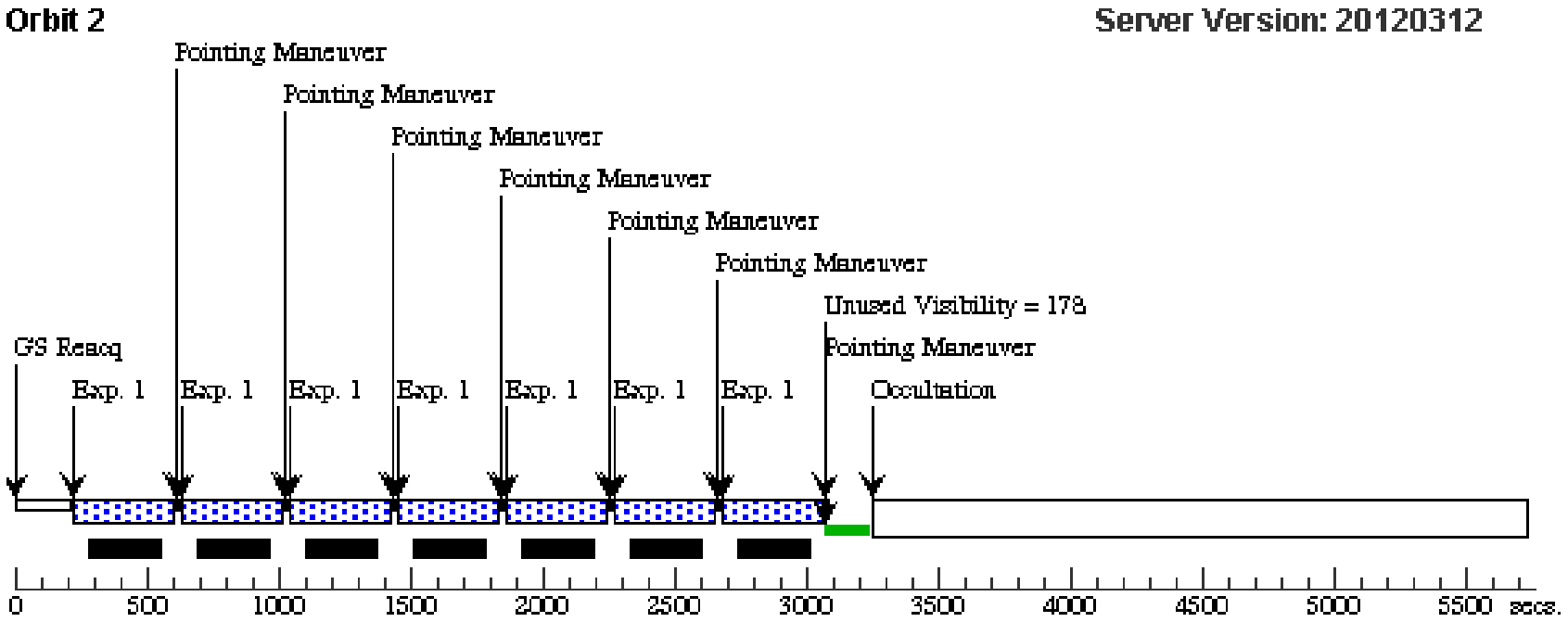
*Comments: The V-magnitude is for the brightest optical star in the field of view.*

**Exposures**

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (1) ARCHES | WFC3/IR, MULTIACCUM, IR-FIX | F153M | SAMP-SEQ=STEP50; NSAMP=12 | GSPAIR S8DO0000 18F2S8DO000001F1 | Pattern 2, Exps 1-1 in Visit 01 (2) | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]*<br>*[==>(Pattern 5)]*<br>*[==>(Pattern 6)]*<br>*[==>(Pattern 7)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 8)]*<br>*[==>(Pattern 9)]*<br>*[==>(Pattern 10)]*<br>*[==>(Pattern 11)]*<br>*[==>(Pattern 12)]*<br>*[==>(Pattern 13)]*<br>*[==>(Pattern 14)]* | ***[2]*** |
| | | | | | | | | *[==>(Pattern 15)]*<br>*[==>(Pattern 16)]*<br>*[==>(Pattern 17)]*<br>*[==>(Pattern 18)]*<br>*[==>(Pattern 19)]*<br>*[==>(Pattern 20)]*<br>*[==>(Pattern 21)]* | ***[3]*** |
| 2 | Short_exp_subarray_end | (1) ARCHES | WFC3/IR, MULTIACCUM, IRSUB512-FIX | F153M | SAMP-SEQ=RAPID; NSAMP=15 | | | *[==>]* | ***[3]*** |
| 3 | Short_exp_subarray_end | (1) ARCHES | WFC3/IR, MULTIACCUM, IRSUB512-FIX | F153M | SAMP-SEQ=RAPID; NSAMP=15 | POS TARG 0.6075,0.4235 | | *[==>]* | ***[3]*** |

Orbit Structure

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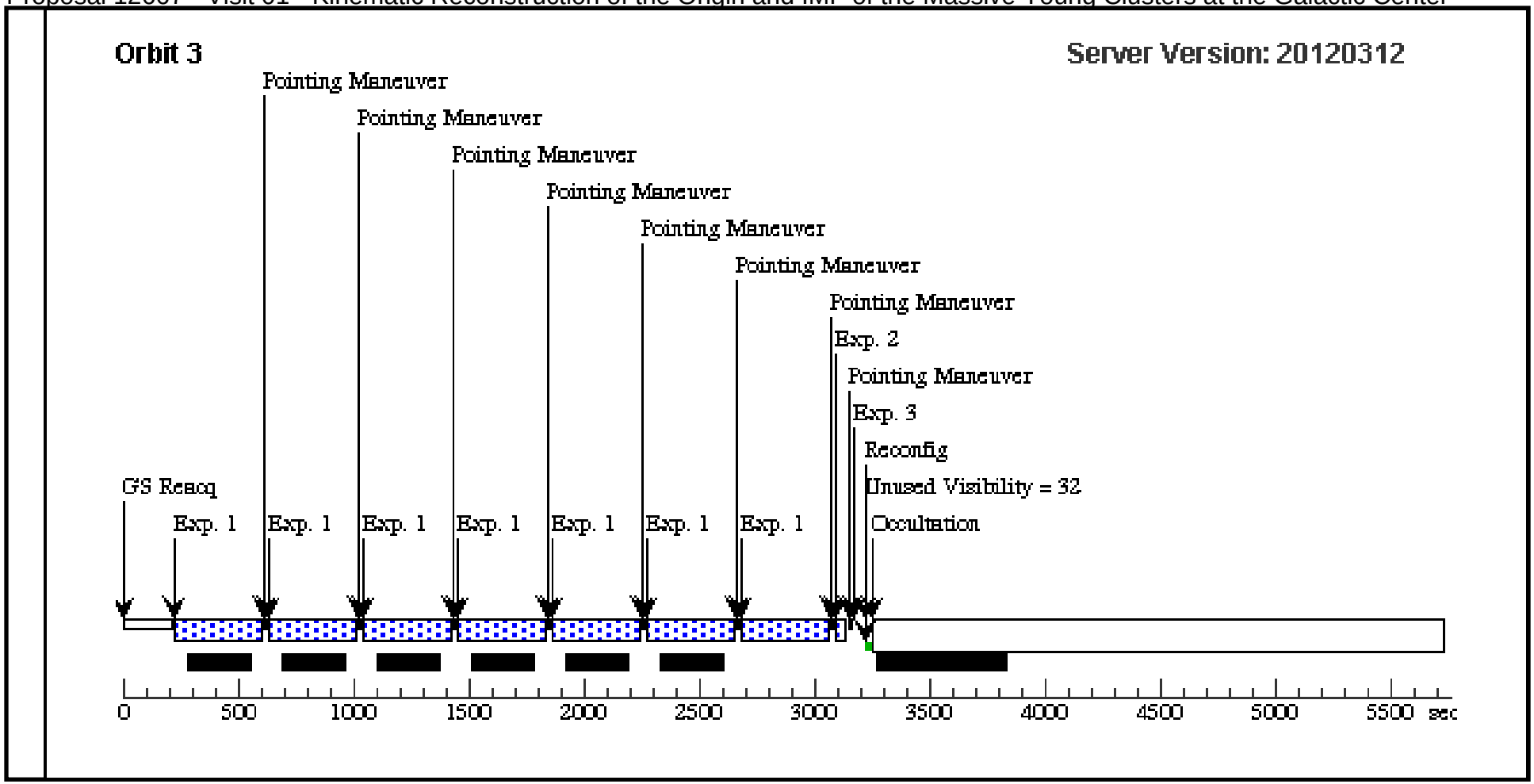
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Unused Visibility = 32
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## Visit

**Proposal 12667, Visit 02, implementation** Wed May 16 01:24:48 GMT 2012

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 93.0D TO 93.0 D

*Comments: Quintuplet F153M Astrometry.*
*These cycle 19 observations should be taken at the exact same orientation and with the same guide stars as our cycle 18 observations of this target. From cycle-18 jitter file ibia02010_jif.fits , these guide-stars are:*

*TARGET DGESTAR SGESTAR*
*Quintuplet S8DH063291F1 S8DO061218F2*

*GS Coordinates:*
*S8DH063291 -- (RA, Dec, Mag): (266.669530, -28.636740, 13.460)*
*S8DO061218 -- RA, Dec, Mag): (266.777210, -28.919100, 12.9820)*

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (2) | Pattern Type=SPIRAL | Coordinate Frame=POS-TARG | | (1) |
| | Purpose=DITHER | Pattern Orientation=11.0 | | |
| | Number Of Points=21 | Angle Between Sides= | | |
| | Point Spacing=0.42 | Center Pattern=false | | |
| | Line Spacing= | | | |

## Fixed Targets

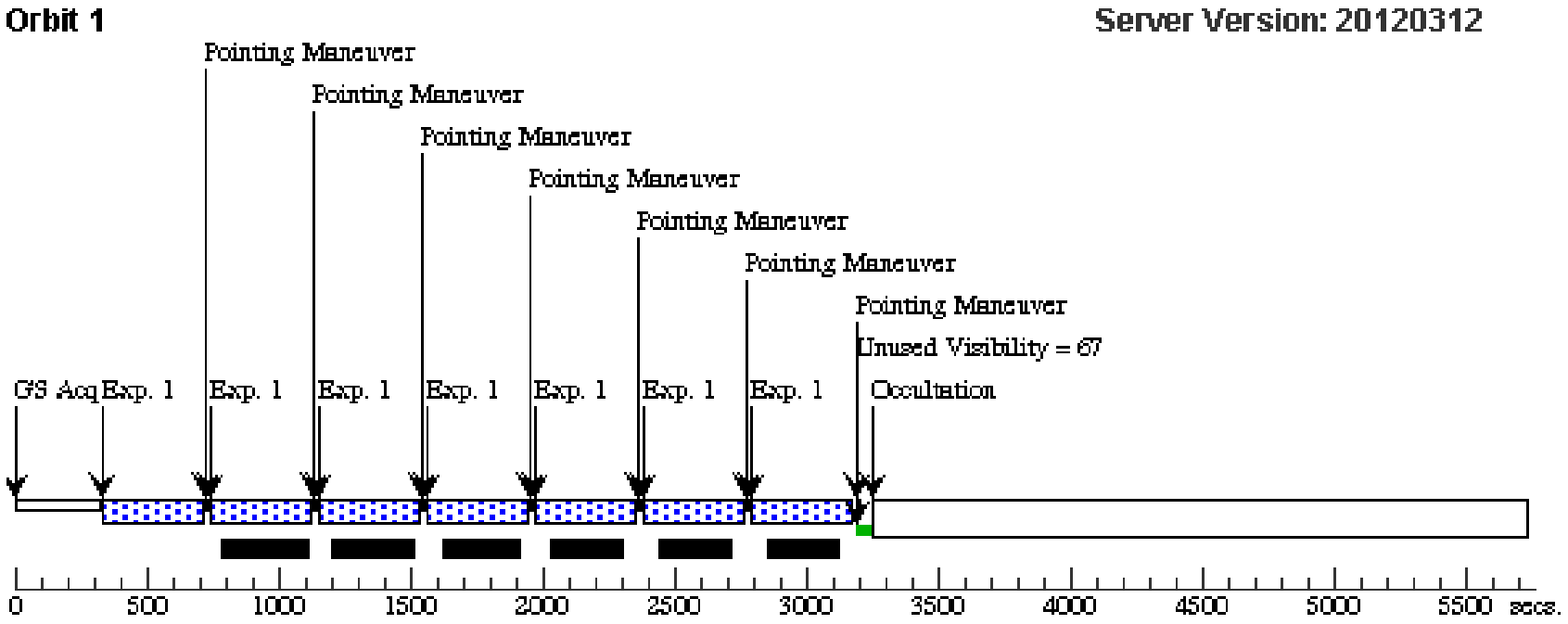
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (2) | QUINTUPLET | RA: 17 46 13.9000 (266.5579167d) | | V=15.6+/-0.1 | Reference Frame: ICRS |
| | | Dec: -28 49 48.00 (-28.83000d) | | J=11.8, | |
| | | Equinox: J2000 | | H=8.9, | |
| | | | | K=7.29 | |

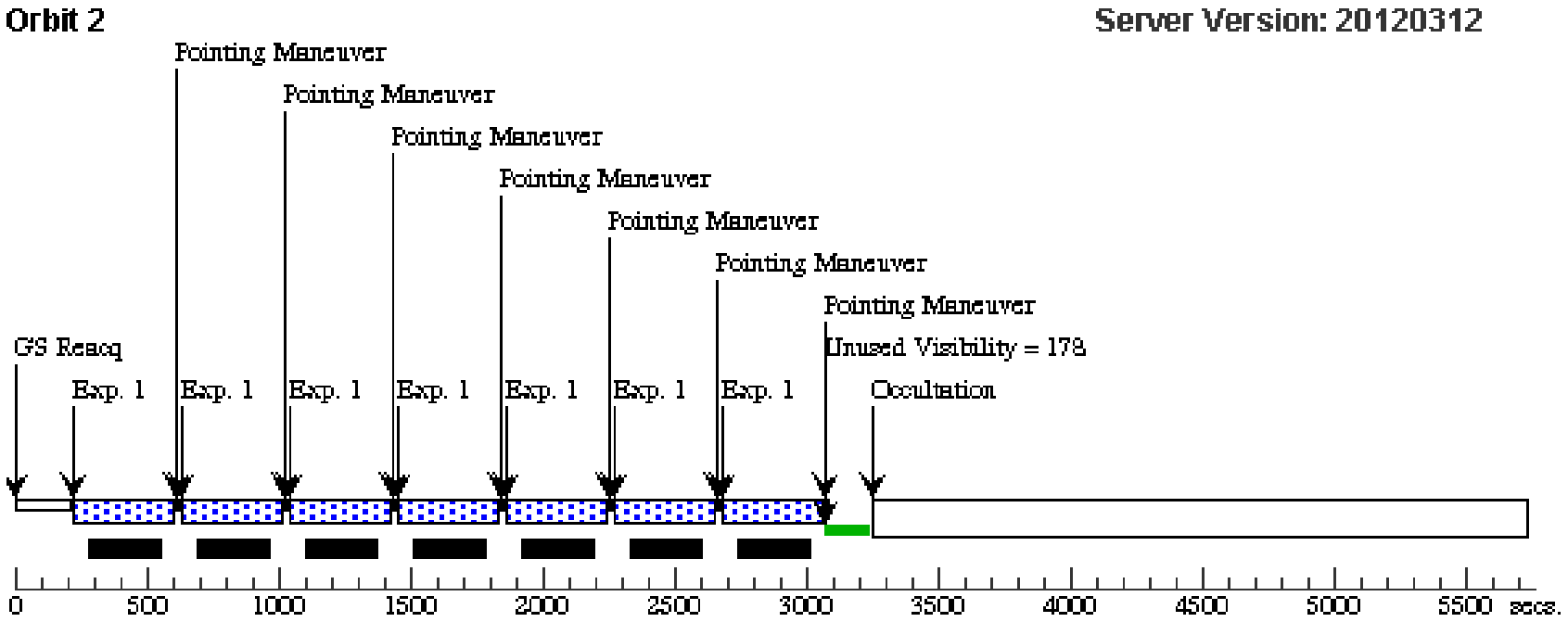
*Comments: The fluxes are for the brightest star in the WFC3 field of view. The brightest optical star is different from the brightest near-infrared star.*

**Exposures**

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (2) QUINTUPLET | WFC3/IR, MULTIACCUM, IR-FIX | F153M | SAMP-SEQ=STEP50; NSAMP=12 | GSPAIR S8DO061218F2S8DH063291F1 | Pattern 2, Exps 1-1 in Visit 02 (2) | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]*<br>*[==>(Pattern 5)]*<br>*[==>(Pattern 6)]*<br>*[==>(Pattern 7)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 8)]*<br>*[==>(Pattern 9)]*<br>*[==>(Pattern 10)]*<br>*[==>(Pattern 11)]*<br>*[==>(Pattern 12)]*<br>*[==>(Pattern 13)]*<br>*[==>(Pattern 14)]* | ***[2]*** |
| | | | | | | | | *[==>(Pattern 15)]*<br>*[==>(Pattern 16)]*<br>*[==>(Pattern 17)]*<br>*[==>(Pattern 18)]*<br>*[==>(Pattern 19)]*<br>*[==>(Pattern 20)]*<br>*[==>(Pattern 21)]* | ***[3]*** |
| 2 | Short_exp_subarray_end | (2) QUINTUPLET | WFC3/IR, MULTIACCUM, IRSUB512-FIX | F153M | SAMP-SEQ=RAPID; NSAMP=15 | | | *[==>]* | ***[3]*** |
| 3 | Short_exp_subarray_end | (2) QUINTUPLET | WFC3/IR, MULTIACCUM, IRSUB512-FIX | F153M | SAMP-SEQ=RAPID; NSAMP=15 | POS TARG 0.6075,0.4235 | | *[==>]* | ***[3]*** |

Orbit Structure

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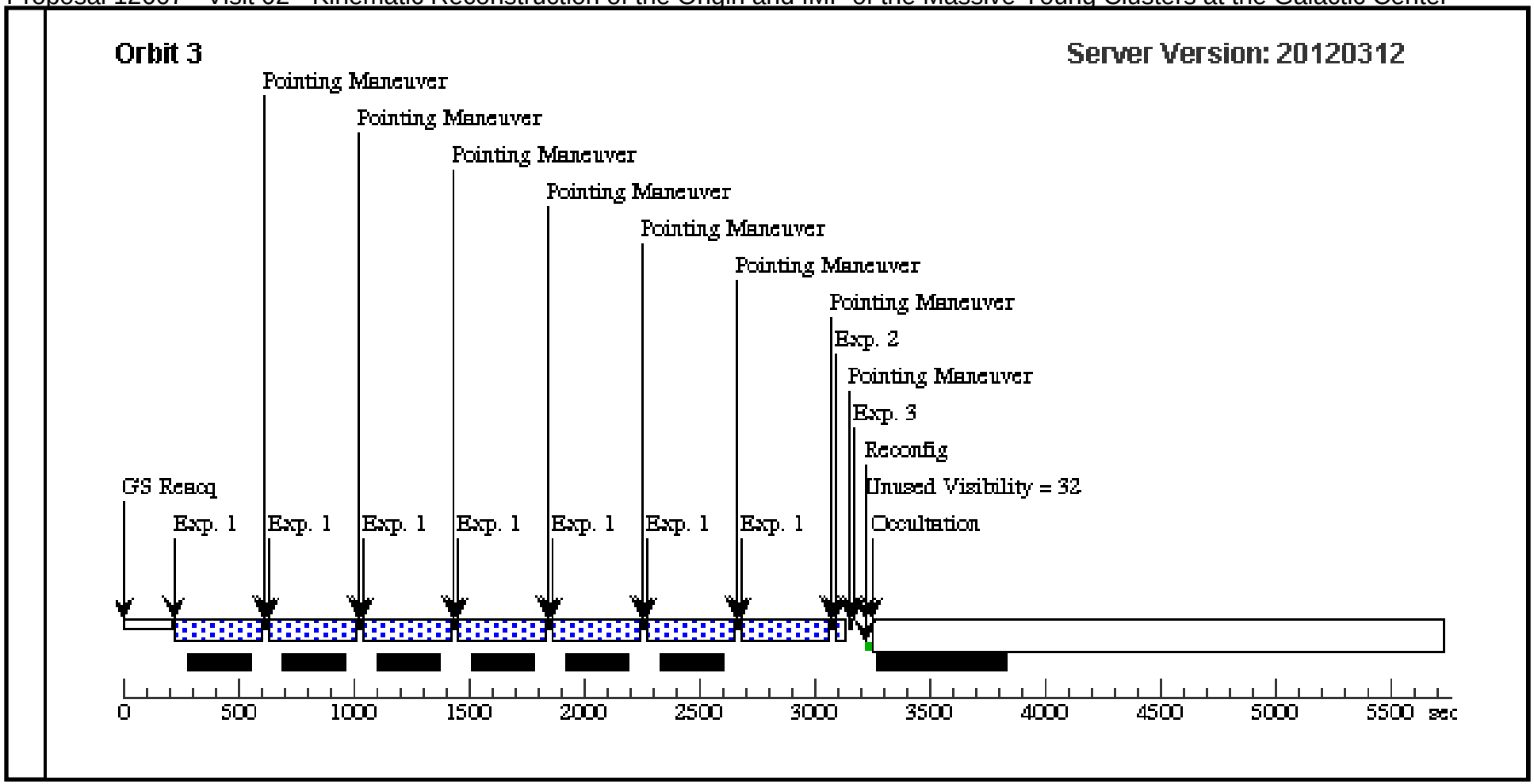
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Exp. 2
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Exp. 3
Reconfig
Unused Visibility = 32
Occultation
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## Visit

**Proposal 12667, Visit 03, implementation** Wed May 16 01:24:49 GMT 2012

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 90.0D TO 90.0 D

*Comments: SgrA F153M Astrometry.*
*These cycle 19 observations should be taken at the exact same orientation and with the same guide stars as our cycle 17/18 observations of this target (based on SgrA cycle 17 jitterfiles).*

*TARGET DGESTAR SGESTAR*
*SgrA S8DM043317F1 S8DO060030F2*

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (2) | Pattern Type=SPIRAL | Coordinate Frame=POS-TARG | | (1) |
| | Purpose=DITHER | Pattern Orientation=11.0 | | |
| | Number Of Points=21 | Angle Between Sides= | | |
| | Point Spacing=0.42 | Center Pattern=false | | |
| | Line Spacing= | | | |

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (3) | SGRA | RA: 17 45 40.0400 (266.4168333d) | | V=14.0+/-0.1 | Reference Frame: ICRS |
| | | Dec: -29 00 28.10 (-29.00781d) | | J=12.2, | |
| | | Equinox: J2000 | | H=9.26, | |
| | | | | K=6.5 | |

*Comments: The fluxes are for the brightest star within the field-of-view for each filter. The brightest star is a different for all 4 filters.*

**Exposures**

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (3) SGRA | WFC3/IR, MULTIACCUM, IR-FIX | F153M | SAMP-SEQ=STEP50; NSAMP=12 | GSPAIR S8DM043317F1S8DO060030F2 | Pattern 2, Exps 1-1 in Visit 03 (2) | *[==>(Pattern 1)]* | ***[1]*** |
| | | | | | | | | *[==>(Pattern 2)]* | |
| | | | | | | | | *[==>(Pattern 3)]* | |
| | | | | | | | | *[==>(Pattern 4)]* | |
| | | | | | | | | *[==>(Pattern 5)]* | |
| | | | | | | | | *[==>(Pattern 6)]* | |
| | | | | | | | | *[==>(Pattern 7)]* | |
| | | | | | | | | *[==>(Pattern 8)]* | ***[2]*** |
| | | | | | | | | *[==>(Pattern 9)]* | |
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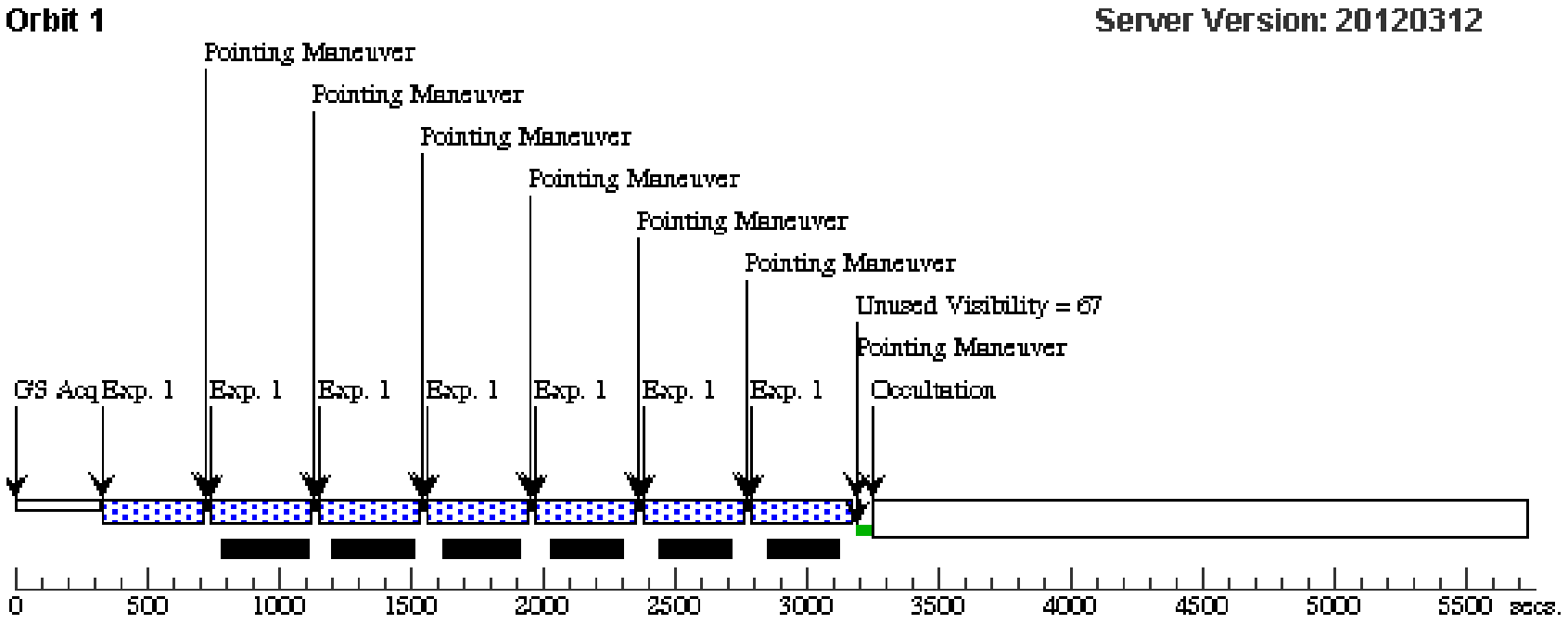
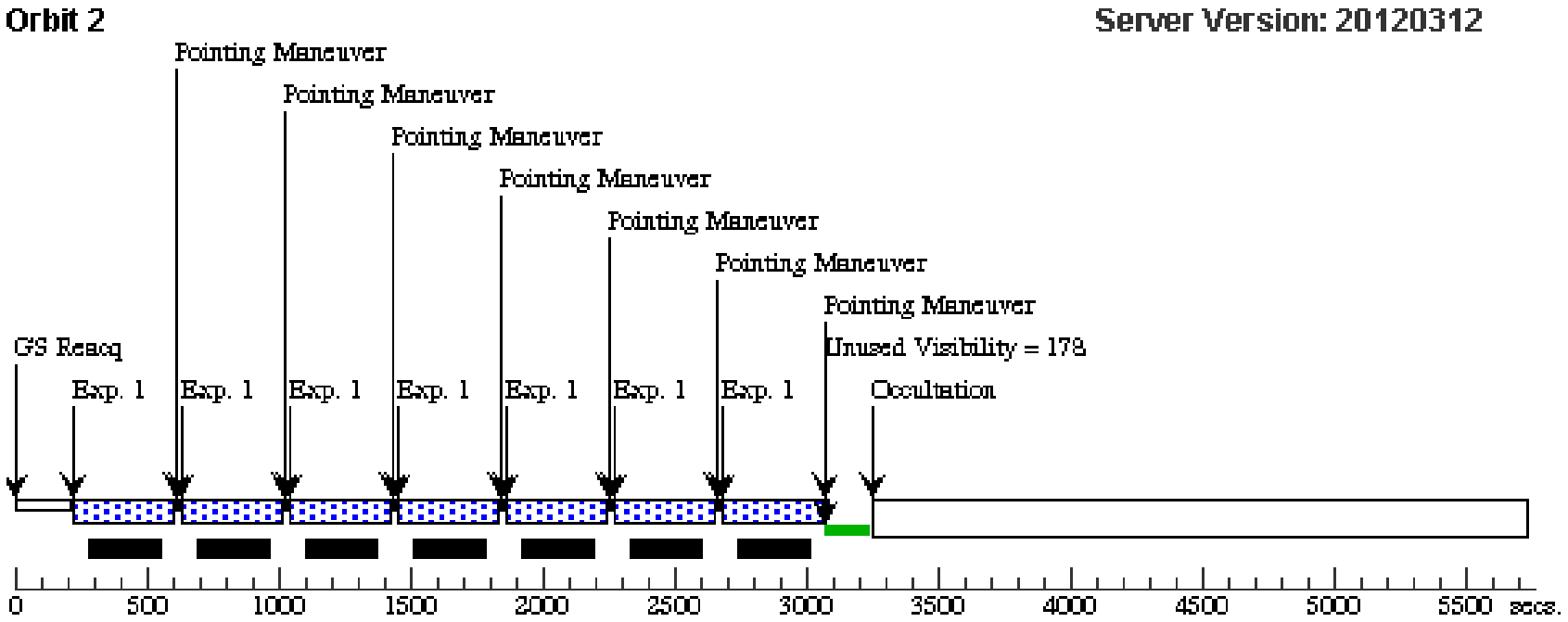
| | | | | | | | | *[==>(Pattern 13)]* | |
| | | | | | | | | *[==>(Pattern 14)]* | |
| | | | | | | | | *[==>(Pattern 15)]* | ***[3]*** |
| | | | | | | | | *[==>(Pattern 16)]* | |
| | | | | | | | | *[==>(Pattern 17)]* | |
| | | | | | | | | *[==>(Pattern 18)]* | |
| | | | | | | | | *[==>(Pattern 19)]* | |
| | | | | | | | | *[==>(Pattern 20)]* | |
| | | | | | | | | *[==>(Pattern 21)]* | |
| 2 | | (3) SGRA | WFC3/IR, MULTIACCUM, IRSUB512-FIX | F153M | SAMP-SEQ=RAPID; NSAMP=15 | | | *[==>]* | ***[3]*** |
| 3 | | (3) SGRA | WFC3/IR, MULTIACCUM, IRSUB512-FIX | F153M | SAMP-SEQ=RAPID; NSAMP=15 | POS TARG 0.6075,0.4235 | | *[==>]* | ***[3]*** |

Orbit Structure

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Unused Visibility = 178
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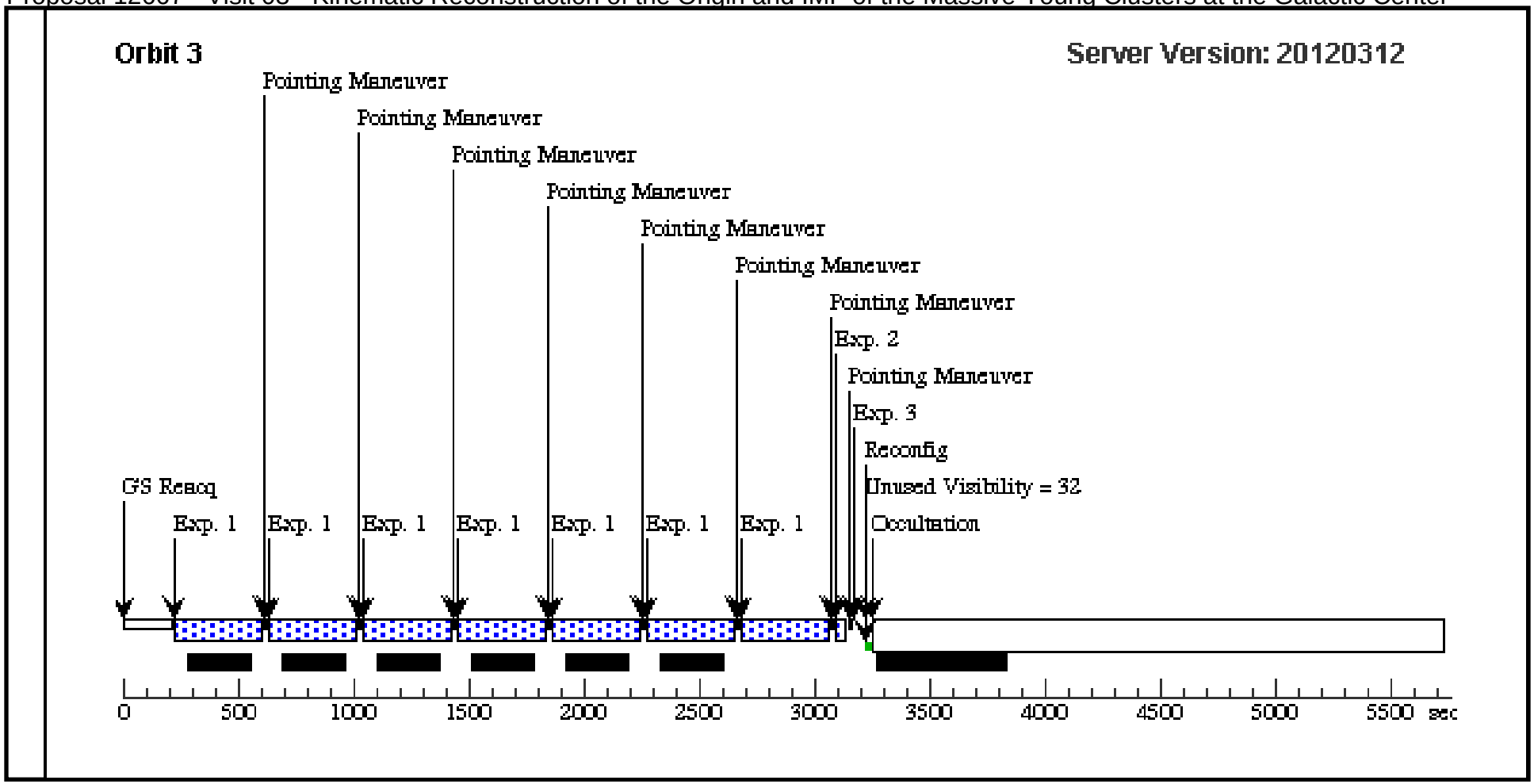
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Unused Visibility = 32
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