# 13642 - The evolutionary link between low-mass X-ray binaries and millisecond radio pulsars

Cycle: 22, Proposal Category: GO

(UV Initiative)

(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) XSSJ12270-4859 | ACS/SBC | 2 | 18-Jul-2014 21:00:27.0 | yes |
| 02 | (1) XSSJ12270-4859 | WFC3/UVIS | 4 | 18-Jul-2014 21:00:29.0 | yes |

6 Total Orbits Used


**ABSTRACT**

Low-mass X-ray binaries (LMXBs) and millisecond radio pulsars (MSRPs) are two different manifestations of neutron stars in binary systems. They are thought to be evolutionary linked, but many questions about their connection remain. Recent discoveries have opened up a new vista to investigate the LMXB/MSRP link. The neutron star XSS J12270-4859 was recently observed to switch between the two different manifestations.

Here, we propose to exploit the unique UV capabilities of the HST to search for the presence of a quiescent accretion disk and to test if the neutron star is hot. This will give insight into its accretion history and the mechanism driving its metamorphosis, which will have direct implications for our understanding of the LMXB/MSRP evolutionary link.

**OBSERVING DESCRIPTION**

Detecting a quiescent accretion disk or a hot neutron star in our target requires observations in the NUV/FUV bands. Observations with the Swift/UVOT (during the current MSRP state) are not sensitive enough to detect the source in the NUV: uvw1 > 19.7 mag (lambda_c~2600 A), uvm2 > 19.7 mag (lambda_c~2246 A), and uvw2 > 20.2 mag (lambda_c~1928 A). This corresponds to NUV fluxes of <5E-17 erg/cm2/s/A, which is well above that expected for a quiescent accretion disk or a hot neutron star (~1-5E-18 erg/cm2/s/A). Our science goals therefore require the unprecedented UV sensitivity of the HST. Given the unknown NUV/FUV magnitude of our target, we propose HST imaging observations.

To be able to determine the shape of the UV spectral energy distribution and to measure UV colors, we request observations using different NUV/FUV filters. To achieve the best sensitivity (our target is not in a crowded field), we chose the WFC3/UVIS for the NUV, and the ACS/SBC for the FUV. For the WFC3/UVIS we will use 3 filters: F218W (lambda_c~2224 A), F225W (lambda_c~2359 A), and F275W (lambda_c~2704 A), and for the ACS/SBC we use 1 filter: F150LP (lambda_c~1500 A).

We used the online WFC3/UVIS and ACS/SBC exposure time calculators (v. 22.2). The distance to our target is 3.6 kpc, and the reddening is E(B-V)=0.577. Detecting a hot neutron star poses the strongest constraints on the science exposures. We assumed a black body of ~3.5E5 K (corresponding to the lowest neutron star temperatures in LMXBs), which yields a flux of ~1E-18 (NUV) and ~1.5E-18 erg/cm2/s/A (FUV). We aim for a SNR>10 at these fluxes. For a remnant accretion disk we expect a higher flux (a black body with a temperature of ~1E4 K, or a luminosity of ~8E30 erg/s, the coldest detected in quiescent LMXBs, would lead to FUV/NUV fluxes of ~5E-18 erg/cm2/s/A), and hence a higher SNR.

We used dither patterns for all science observations and for the WFC2/UVIS exposure time calculation we took into account lamp flashes to ensure that the minimum background for proper CTE is reached. Some of the required UVIS exposures were >3600 s, which we then split into two. We require 2 orbits of ACS/SBC observations, and 4 orbits of WFC3/UVIS observations, together totalling 6 orbits. These are combined into a single visit.

## Visit

**Proposal 13642, Visit 01** Sat Jul 19 01:00:31 GMT 2014

**Diagnostic Status: No Diagnostics**

Scientific Instruments: ACS/SBC

Special Requirements: (none)

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (2) | Pattern Type=ACS-SBC-DITHER-LINE<br>Purpose=DITHER<br>Number Of Points=3<br>Point Spacing=0.472<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=44.4<br>Angle Between Sides=<br>Center Pattern=false | | (1) |

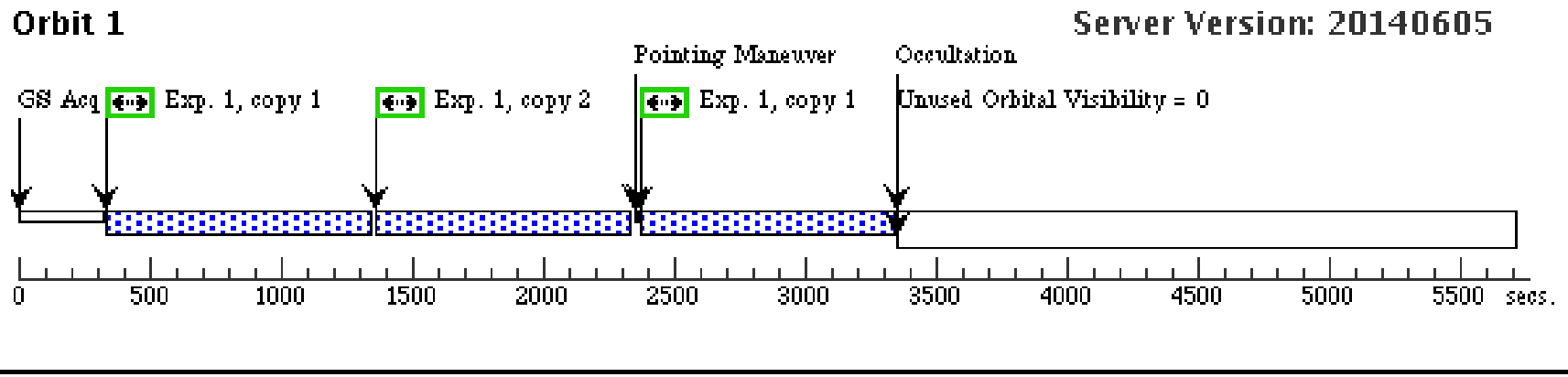
## Fixed Targets

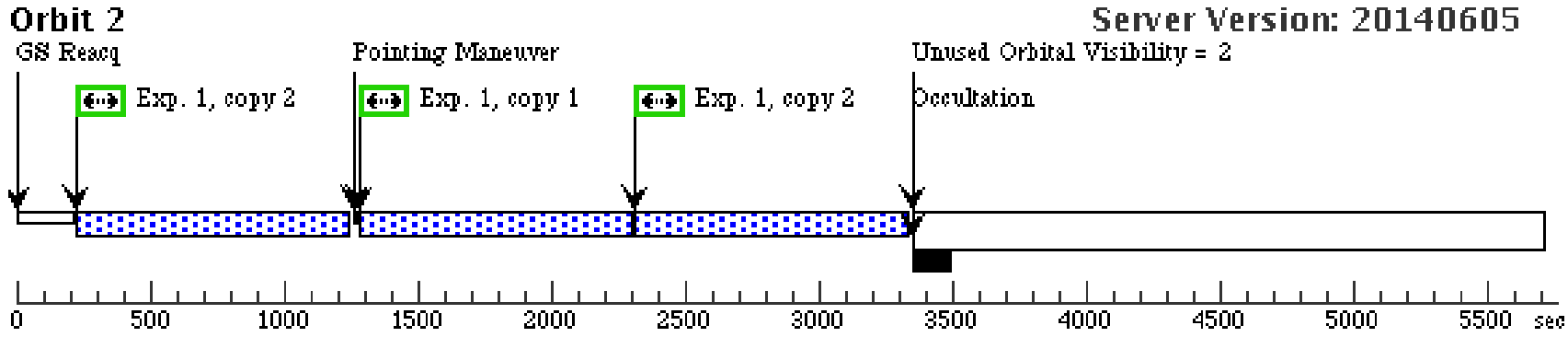
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | XSSJ12270-4859 | RA: 12 27 58.7480 (186.9947833d)<br>Dec: -48 53 42.88 (-48.89524d)<br>Equinox: J2000 | | V=18 | Reference Frame: ICRS |

## Exposures

| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ACIS-SBC-F150LP (ACS.im.621279) | (1) XSSJ12270-4859 | ACS/SBC, ACCUM, SBC | F150LP | | | Pattern 2, Exps 1-1 in Visit 01 (2) | 965 Secs X 2 (5838 Secs) | |
| | | | | | | | | *[==>948.0 Secs (Pattern 1, Copy 1)]*<br>*[==>948.0 Secs (Pattern 1, Copy 2)]*<br>*[==>948.0 Secs (Pattern 2, Copy 1)]* | ***[1]*** |
| | | | | | | | | *[==>998.0 Secs (Pattern 2, Copy 2)]*<br>*[==>998.0 Secs (Pattern 3, Copy 1)]*<br>*[==>998.0 Secs (Pattern 3, Copy 2)]* | ***[2]*** |

Orbit Structure



## Visit

**Proposal 13642, Visit 02** Sat Jul 19 01:00:31 GMT 2014

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

## Patterns

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

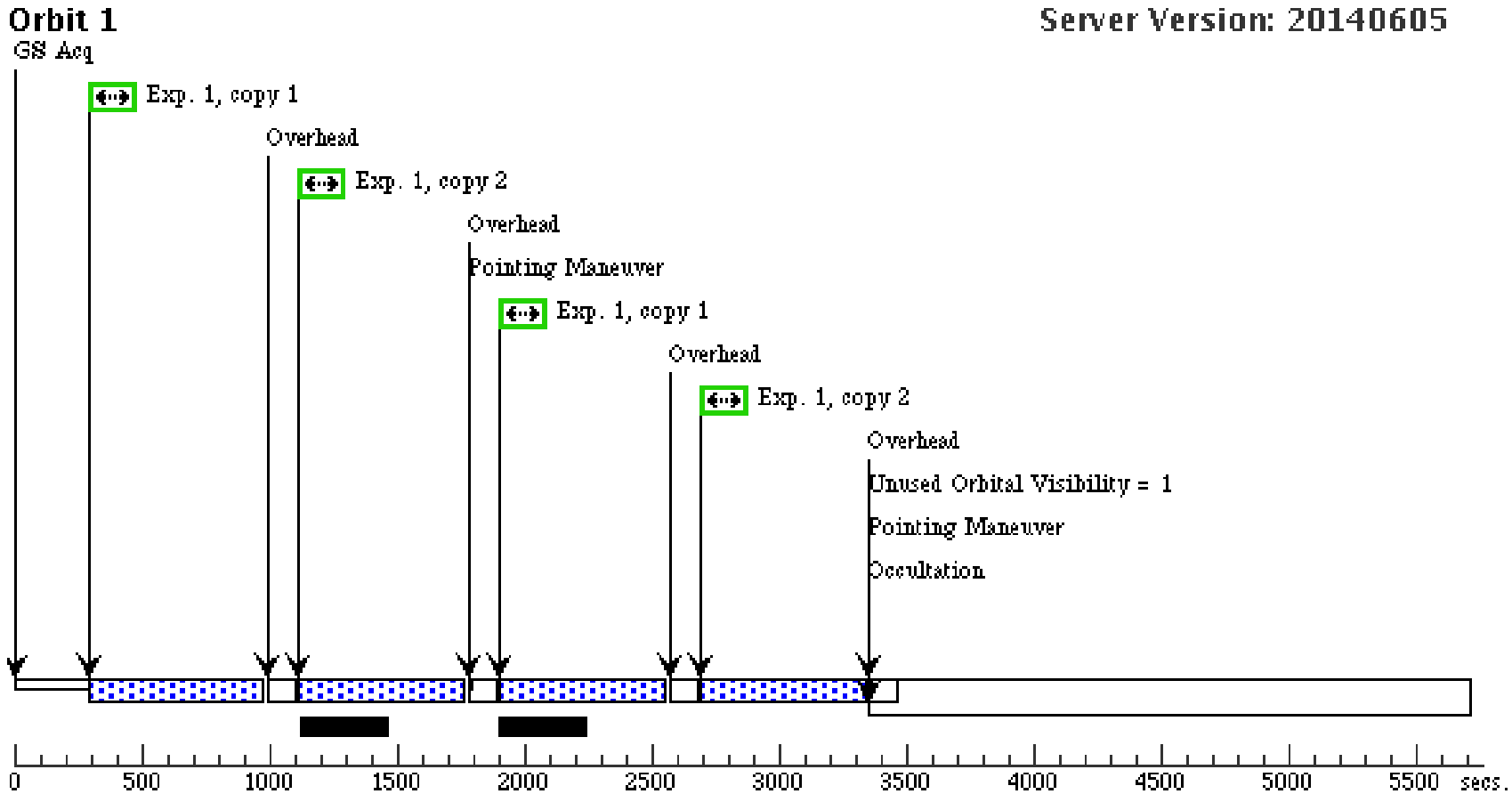
## Fixed Targets

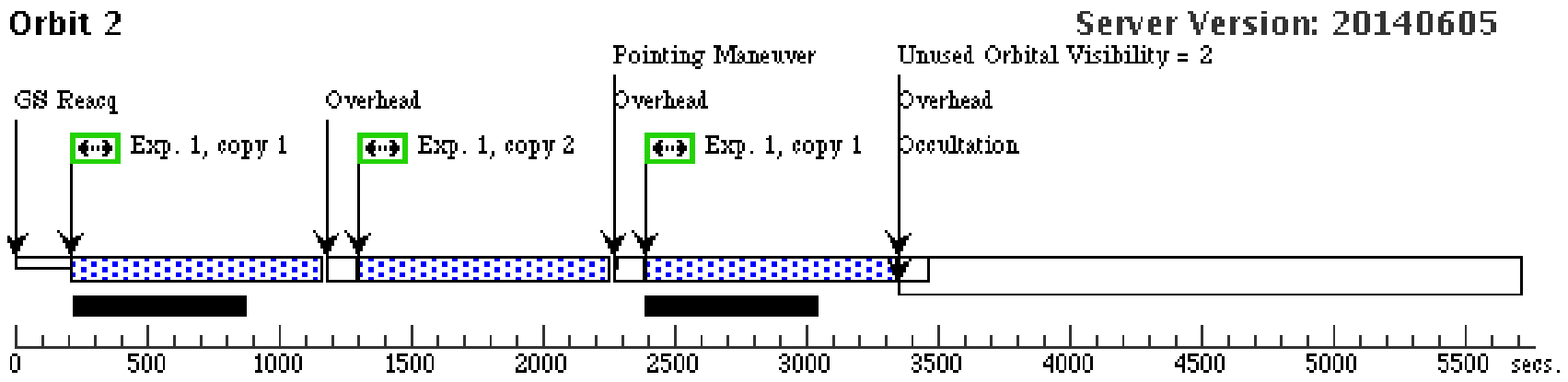
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | XSSJ12270-4859 | RA: 12 27 58.7480 (186.9947833d)<br>Dec: -48 53 42.88 (-48.89524d)<br>Equinox: J2000 | | V=18 | Reference Frame: ICRS |

## Exposures

| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | WFC3-UVIS-F218W-exp1 (WFC3UVIS.im.621281) | (1) XSSJ12270-4859 | WFC3/UVIS, ACCUM, UVIS | F218W | FLASH=4 | | Pattern 3, Exps 1-1 in Visit 02 (3) | 650 Secs X 2 (6436 Secs) | |
| | | | | | | | | *[==>655.0 Secs (Pattern 1, Copy 1)]*<br>*[==>655.0 Secs (Pattern 1, Copy 2)]*<br>*[==>655.0 Secs (Pattern 2, Copy 1)]*<br>*[==>655.0 Secs (Pattern 2, Copy 2)]* | ***[1]*** |
| | | | | | | | | *[==>954.0 Secs (Pattern 3, Copy 1)]*<br>*[==>954.0 Secs (Pattern 3, Copy 2)]*<br>*[==>954.0 Secs (Pattern 4, Copy 1)]* | ***[2]*** |
| | | | | | | | | *[==>954.0 Secs (Pattern 4, Copy 2)]* | ***[3]*** |
| 2 | WFC3-UVIS-F225W (WFC3UVIS.im.621284) | (1) XSSJ12270-4859 | WFC3/UVIS, ACCUM, UVIS | F225W | FLASH=7 | | Pattern 3, Exps 2-2 in Visit 02 (3) | 534.5 Secs (2342 Secs) | |
| | | | | | | | | *[==>585.5 Secs (Pattern 1)]*<br>*[==>585.5 Secs (Pattern 2)]*<br>*[==>585.5 Secs (Pattern 3)]* | ***[3]*** |
| | | | | | | | | *[==>585.5 Secs (Pattern 4)]* | ***[4]*** |
| 3 | WFC3-UVIS-F275W (WFC3UVIS.im.621285) | (1) XSSJ12270-4859 | WFC3/UVIS, ACCUM, UVIS | F275W | FLASH=8 | | Pattern 3, Exps 3-3 in Visit 02 (3) | 476.5 Secs (1980 Secs) | |
| | | | | | | | | *[==>495 Secs (Pattern 1)]*<br>*[==>495 Secs (Pattern 2)]*<br>*[==>495 Secs (Pattern 3)]*<br>*[==>495 Secs (Pattern 4)]* | ***[4]*** |

Orbit Structure

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GS Reacq
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Overhead
Exp. 1, copy 2
Pointing Maneuver
Overhead
Exp. 1, copy 1
Unused Orbital Visibility = 2
Overhead
Occultation
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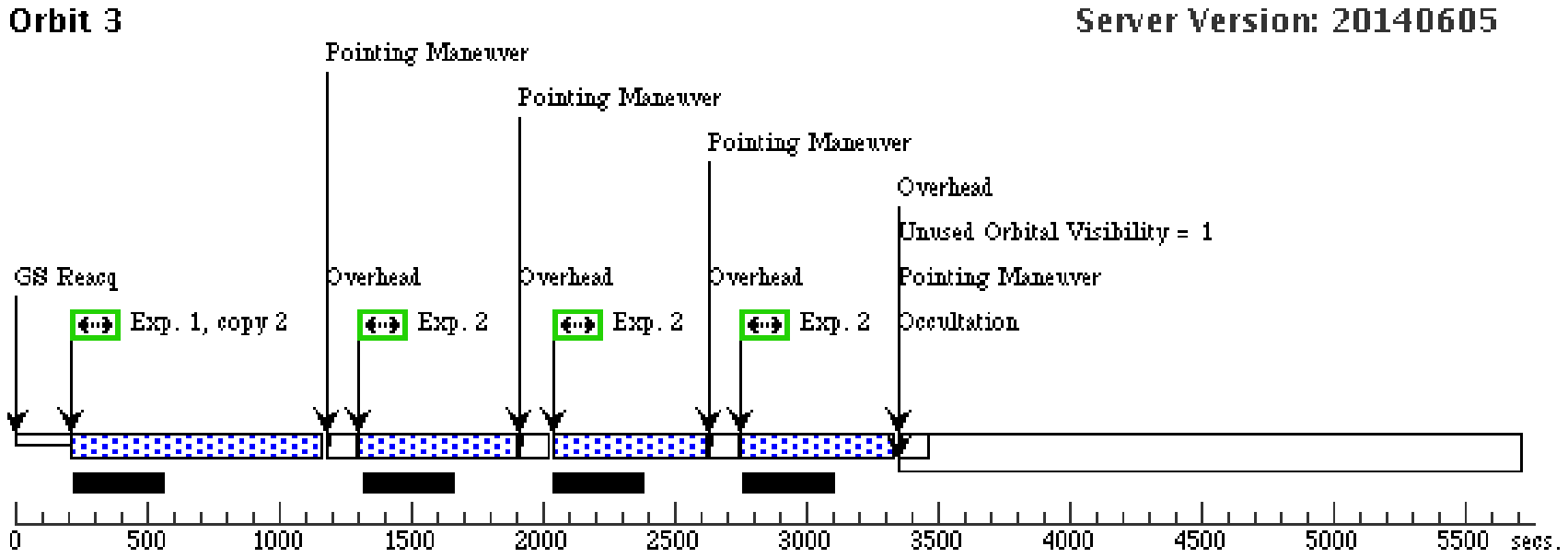
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 3
Server Version: 20140605
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Overhead
Unused Orbital Visibility = 1
Pointing Maneuver
Occultation
GS Reacq
Exp. 1, copy 2
Overhead
Exp. 2
Overhead
Exp. 2
Overhead
Exp. 2
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1500
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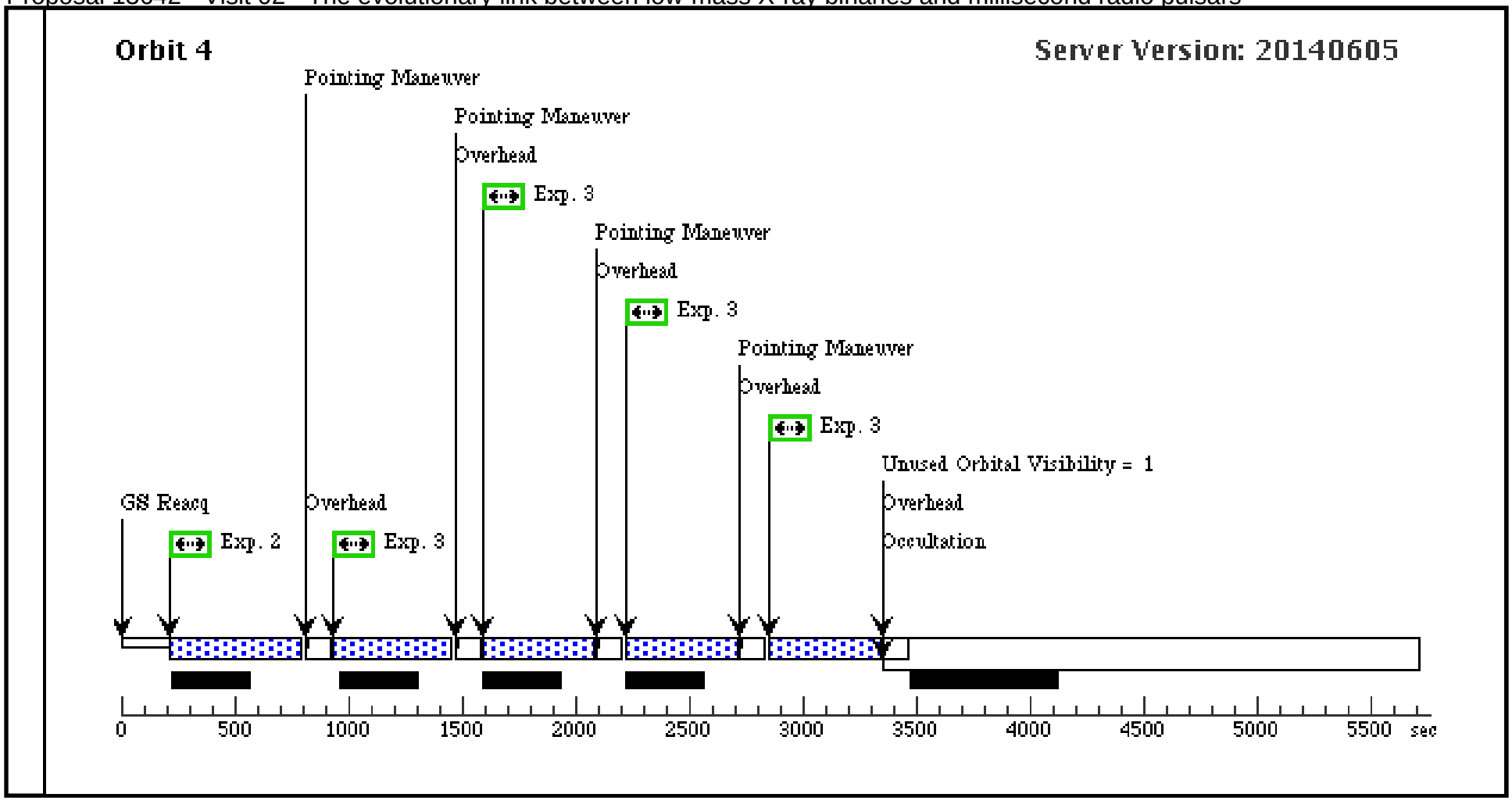
secs.


Orbit 4
Server Version: 20140605
Pointing Maneuver
Pointing Maneuver
Overhead
Exp. 3
Pointing Maneuver
Overhead
Exp. 3
Pointing Maneuver
Overhead
Exp. 3
Unused Orbital Visibility = 1
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Occultation
GS Reacq
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