# 13456 - Searching for 300,000 Degree Gas in the Core of the Phoenix Cluster with HST-COS

Cycle: 21, Proposal Category: GO

(Availability Mode: SUPPORTED)

**INVESTIGATORS**



| *Name* | *Institution* | *E-Mail* |
|---|---|---|
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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 | (2) PHOENIX-CENTER<br>(4) PHOENIX-SE | COS/FUV<br>COS/NUV | 7 | 15-May-2014 16:01:00.0 | yes |
| 02 | (1) PHOENIX | COS/FUV<br>COS/NUV | 7 | 15-May-2014 16:01:02.0 | yes |
| 52 | (2) PHOENIX-CENTER<br>(3) PHOENIX-NW | COS/FUV<br>COS/NUV | 7 | 15-May-2014 16:01:05.0 | yes |

21 Total Orbits Used

**ABSTRACT**

The high central density of the intracluster medium in some galaxy clusters suggests that the hot 10,000,000K gas should cool completely in less than a Hubble time. In these clusters, simple cooling models predict 100-1000 solar masses per year of cooling gas should fuel massive starbursts in the central galaxy. The fact that the typical central cluster galaxy is a massive, "red and dead" elliptical galaxy, with little evidence for a cool ISM, has led to the realization of the "cooling flow problem". It is now thought that mechanical feedback from the central supermassive blackhole, in the form of radio-blown bubbles, is offsetting cooling, leading to an exceptionally precise (residuals of less than 10 percent) balance between cooling and feedback in nearly every galaxy cluster in the local Universe. In the recently-discovered Phoenix cluster, where z=0.596, we observe an 800 solar mass per year starburst within the central galaxy which accounts for about 30 percent of the classical cooling prediction for this system. We speculate that this may represent the first "true" cooling flow, with the factor of 3 difference between cooling and star formation being attributed to star formation efficiency, rather than a problem with cooling. In order to test these predictions, we propose far-UV spectroscopic observations of the OVI 1032A emission line, which probes 10^5.5K gas, in the central galaxy of the Phoenix cluster. If detected at the expected levels, this would provide compelling evidence that the starburst is, indeed, fueled by runaway cooling of the intracluster medium, confirming the presence of the first, bonafide cooling flow.

**OBSERVING DESCRIPTION**

The primary goal of this program is to obtain spectra of the OVI (1032,1038) doublet, which will be redshifted to 1648,1658A. Our secondary goal is to obtain broad UV continuum coverage.

We are imaging two relatively diffuse/clumpy regions, neither of which are centrally peaked in UV brightness. Thus, pointing revision via ACQ/SEARCH is not possible. We instead must center on a nearby star (~60" away) and perform offsets. According to the COS users manual, such offsets should be accurate enough for our purposes.

All of our observations are done in TIME-TAG mode. This temporal sampling will allow us to exclude poor quality data and get improved thermal correction and background removal. We separate our visits into 7 orbits, where each orbit uses one of four different FP-POS (1,2,3,4,2,3,4). This observing strategy is adopted to reduce the fixed pattern noise and fill up the wavelength hole produced by the chip gap without excessive overheads.

Since our targets are faint (<0.001 cts/s), we use a BUFFER-TIME equal to the exposure time minus 110s, as suggested by Julia Duval for a similar

2012 program.

We choose a central wavelength of 1577 in order to keep the OVI line (1650A) as far from the chip gap as possible. We are open to suggestions on this, if we are pushing the line into a low-sensitivity regime.

## Visit

**Proposal 13456, Phoenix - Southeast (01), implementation** Thu May 15 20:01:07 GMT 2014

**Diagnostic Status: Warning**

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

## Diagnostics

(Phoenix - Southeast (01)) Warning (Orbit Planner): INEFFICIENT ORDERING OF FP-POS POSITIONS

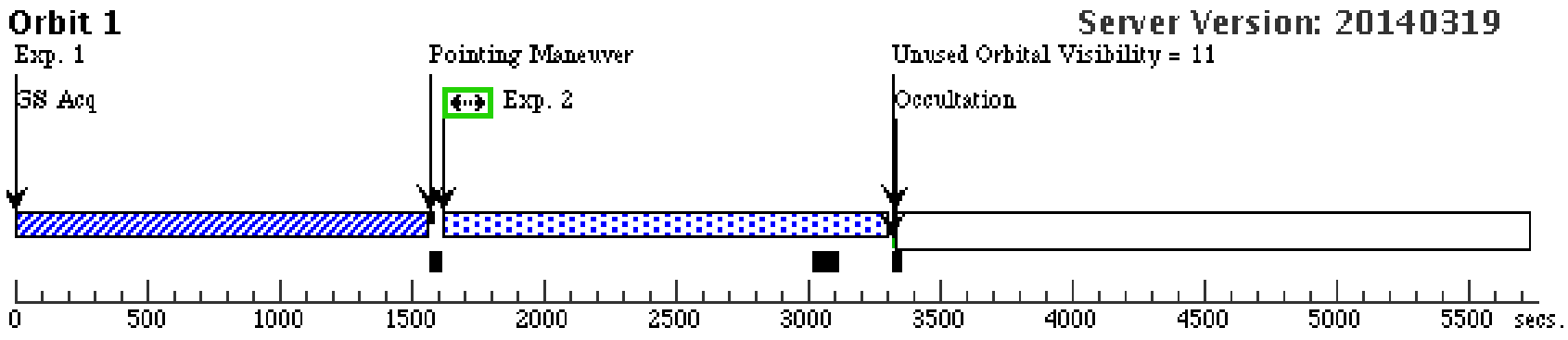
## Fixed Targets

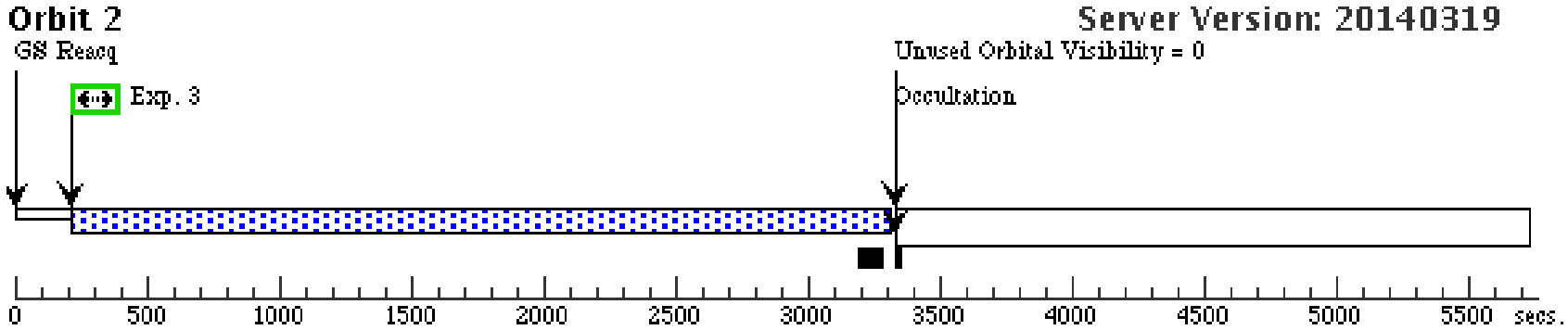
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (2) | PHOENIX-CENTER | RA: 23 44 43.8930 (356.1828875d)<br>Dec: -42 43 12.58 (-42.72016d)<br>Equinox: J2000 | | V=18.0 | Reference Frame: ICRS |
| *Comments: Center of galaxy, to be used for COS centroiding* | | | | | |
| (4) | PHOENIX-SE | Offset from PHOENIX-CENTER<br>RA Offset: 0.039 Secs<br>Dec Offset: -0.83 Arcsec | | V=18.0 | Offset Position (PHOENIX-SE) |

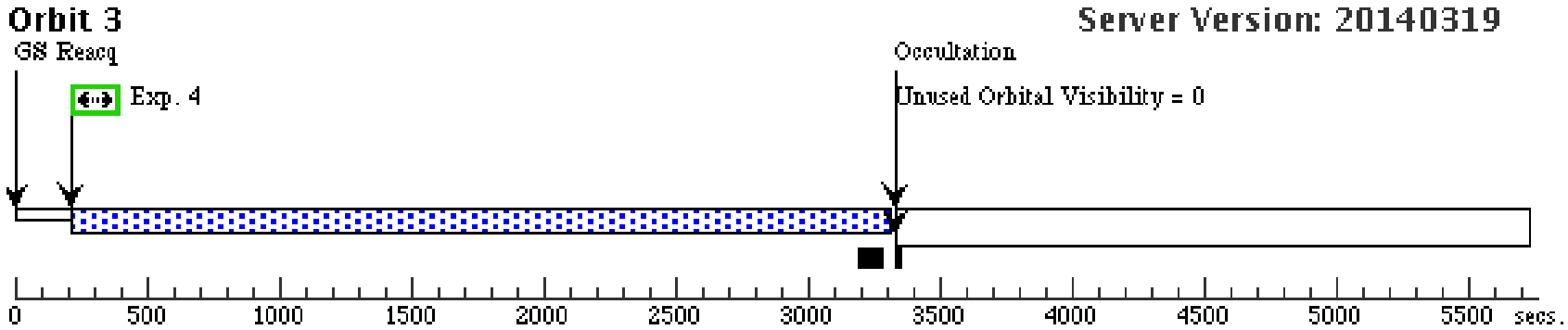
**Exposures**

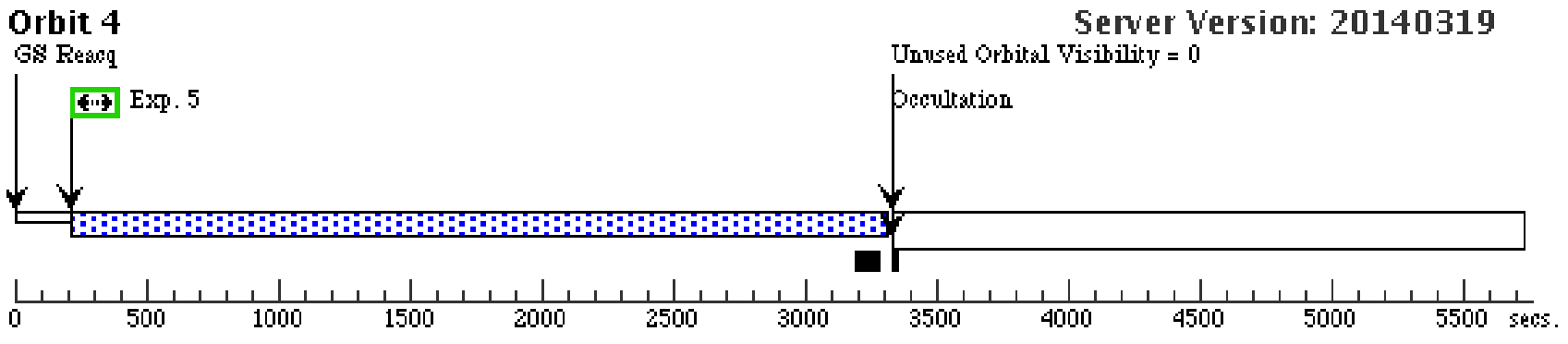
| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Phoenix A acquisition (COS.ta.510181) | (2) PHOENIX-CENTER | COS/NUV, ACQ/IMAGE, PSA | MIRRORA | | | | 580 Secs (580 Secs)<br>*[==>]* | *[1]* |
| 2 | (COS.sp.510045) | (4) PHOENIX-SE | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=1204; FLASH=YES; FP-POS=1; EXTENDED=YES | | | 1469 Secs (1469 Secs)<br>*[==>]* | *[1]* |
| 3 | (COS.sp.510045) | (4) PHOENIX-SE | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=2; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[2]* |
| 4 | (COS.sp.510045) | (4) PHOENIX-SE | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=3; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[3]* |
| 5 | (COS.sp.510045) | (4) PHOENIX-SE | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=4; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[4]* |
| 6 | (COS.sp.510045) | (4) PHOENIX-SE | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=2; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[5]* |
| 7 | (COS.sp.510045) | (4) PHOENIX-SE | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=3; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[6]* |
| 8 | (COS.sp.510045) | (4) PHOENIX-SE | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=4; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[7]* |

Orbit Structure

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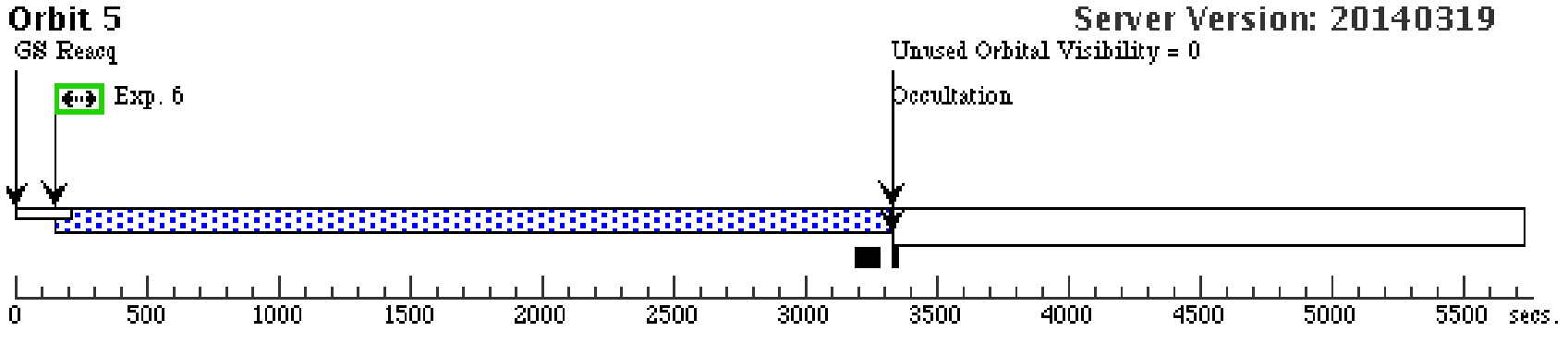
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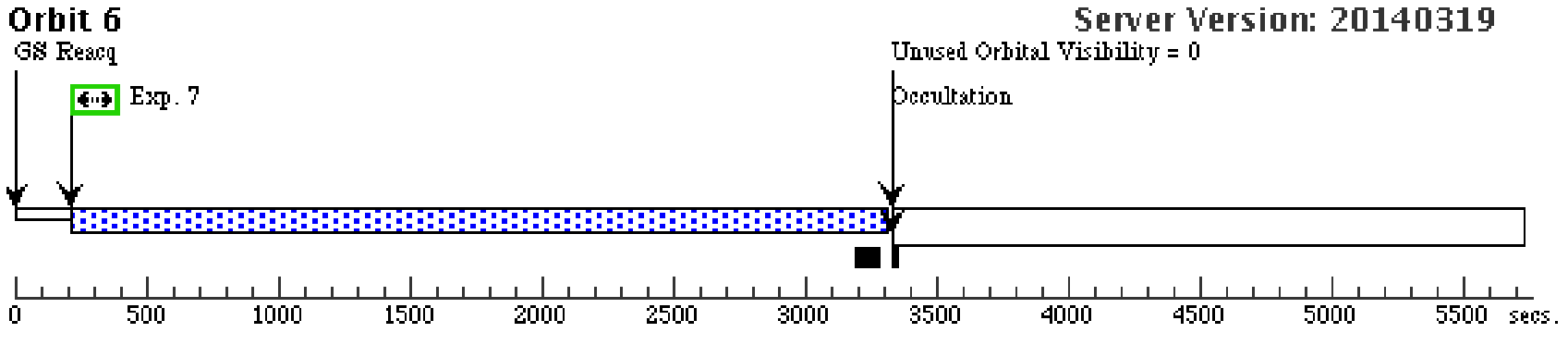
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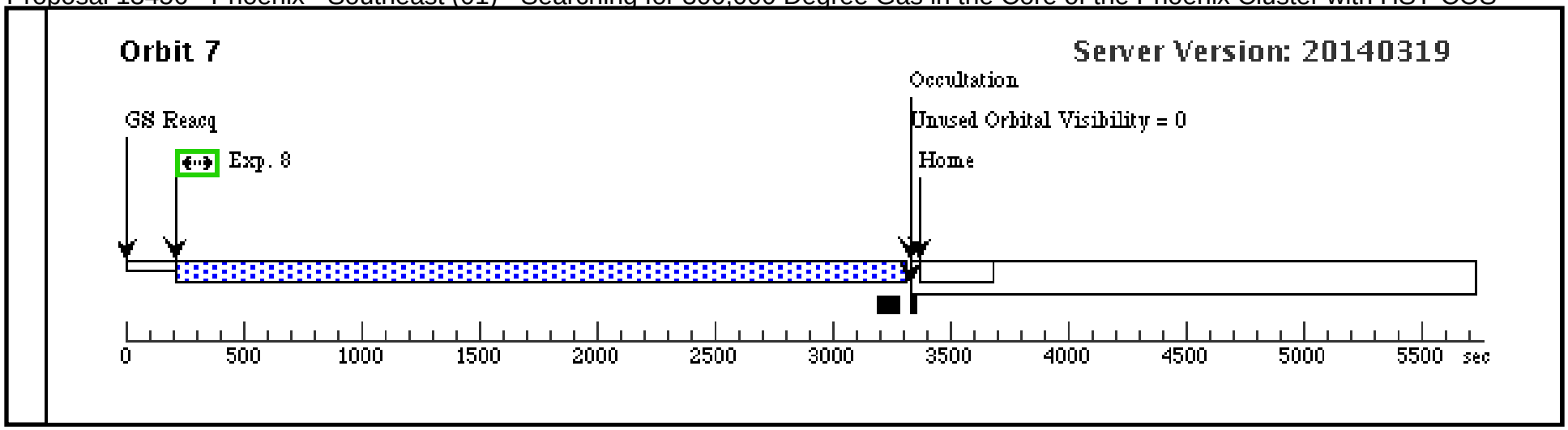
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## Visit

**Proposal 13456, Phoenix - North (02), failed** Thu May 15 20:01:07 GMT 2014

**Diagnostic Status: Warning**

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

## Diagnostics

(Phoenix - North (02)) Warning (Orbit Planner): POS TARG OUTSIDE OF APERTURE NO ORIENT
(Phoenix - North (02)) Warning (Orbit Planner): POS TARG OUTSIDE OF APERTURE NO ORIENT
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(Phoenix - North (02)) Warning (Orbit Planner): POS TARG OUTSIDE OF APERTURE
(Phoenix - North (02)) Warning (Orbit Planner): POS TARG OUTSIDE OF APERTURE NO ORIENT
(Phoenix - North (02)) Warning (Orbit Planner): POS TARG OUTSIDE OF APERTURE

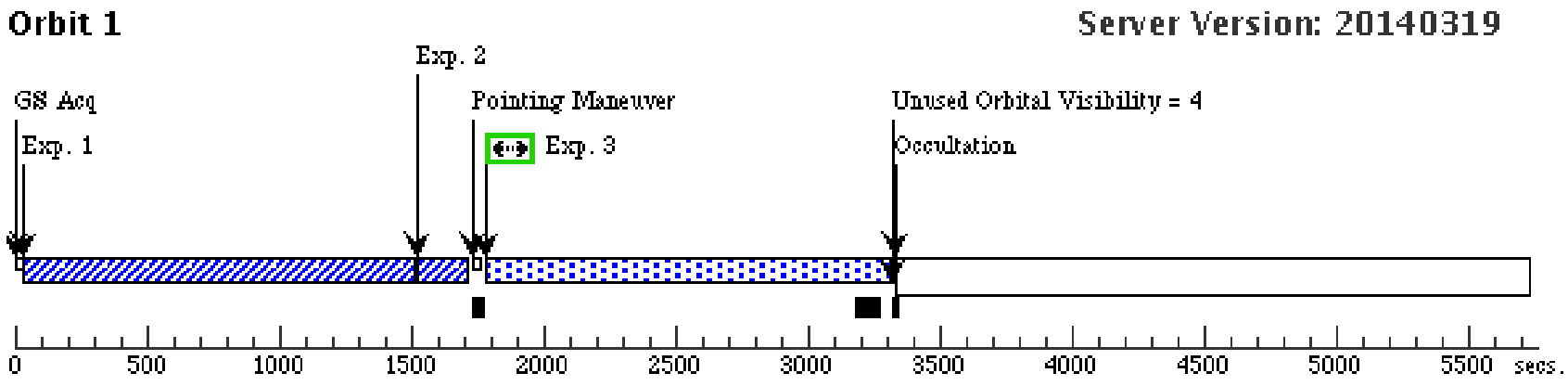
## Fixed Targets

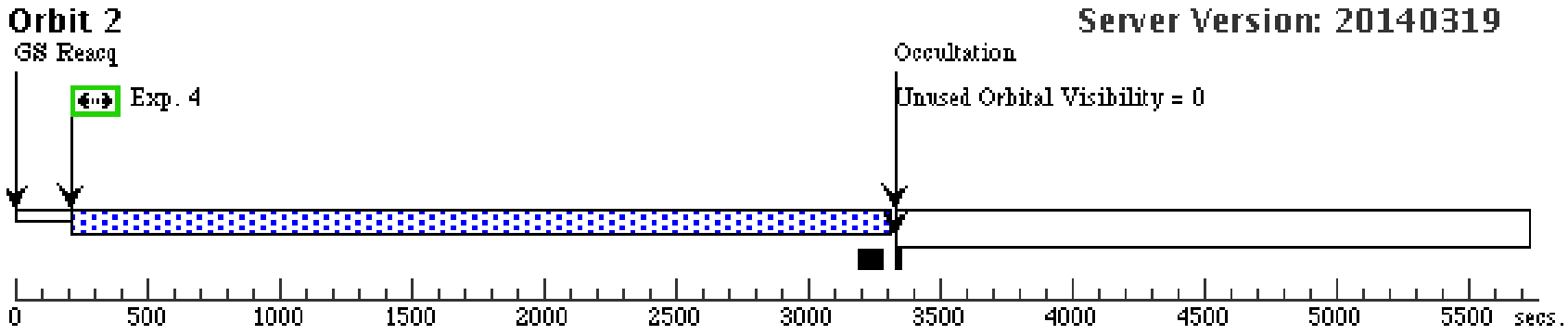
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | PHOENIX | RA: 23 44 46.8902 (356.1953758d)<br>Dec: -42 42 25.19 (-42.70700d)<br>Equinox: J2000 | | V=16.0<br>20.933 (GALEX NUV) | Reference Frame: ICRS |

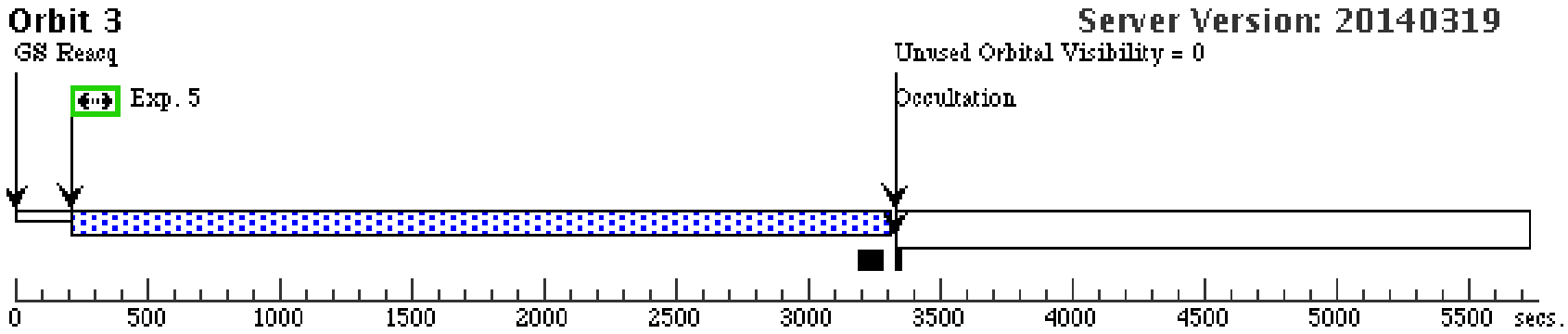
**Exposures**

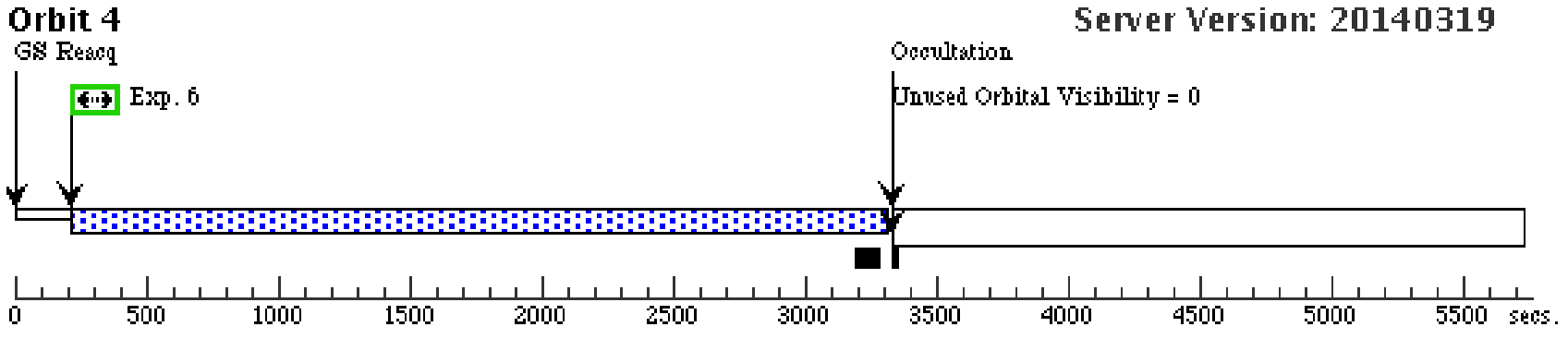
| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Bright star coarse acquisition (COS.ta.510183) | (1) PHOENIX | COS/NUV, ACQ/SEARCH, PSA | MIRRORA | CENTER=BRIGHTEST; SCAN-SIZE=3; STEP-SIZE=1.767 | | | 100 Secs (100 Secs)<br>*[==>]* | ***[1]*** |
| 2 | Bright star fine acquisition (COS.ta.510181) | (1) PHOENIX | COS/NUV, ACQ/IMAGE, PSA | MIRRORA | | | | 46 Secs (46 Secs)<br>*[==>]* | ***[1]*** |
| 3 | (COS.sp.510045) | (1) PHOENIX | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=1204; FLASH=YES; FP-POS=1; EXTENDED=YES | POS TARG -8.4767 23689658884,-55.98962938415026 | | 1314 Secs (1314 Secs)<br>*[==>]* | ***[1]*** |
| 4 | (COS.sp.510045) | (1) PHOENIX | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=2; EXTENDED=YES | POS TARG -8.4767 23689658884,-55.98962938415026 | | 3047 Secs (3047 Secs)<br>*[==>]* | ***[2]*** |
| 5 | (COS.sp.510045) | (1) PHOENIX | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=3; EXTENDED=YES | POS TARG -8.4767 23689658884,-55.98962938415026 | | 3047 Secs (3047 Secs)<br>*[==>]* | ***[3]*** |
| 6 | (COS.sp.510045) | (1) PHOENIX | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=4; EXTENDED=YES | POS TARG -8.4767 23689658884,-55.98962938415026 | | 3047 Secs (3047 Secs)<br>*[==>]* | ***[4]*** |
| 7 | (COS.sp.510045) | (1) PHOENIX | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=2; EXTENDED=YES | POS TARG -8.4767 23689658884,-55.98962938415026 | | 3047 Secs (3047 Secs)<br>*[==>]* | ***[5]*** |
| 8 | (COS.sp.510045) | (1) PHOENIX | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=3; EXTENDED=YES | POS TARG -8.4767 23689658884,-55.98962938415026 | | 3047 Secs (3047 Secs)<br>*[==>]* | ***[6]*** |
| 9 | (COS.sp.510045) | (1) PHOENIX | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=4; EXTENDED=YES | POS TARG -8.4767 23689658884,-55.98962938415026 | | 3047 Secs (3047 Secs)<br>*[==>]* | ***[7]*** |

Orbit Structure

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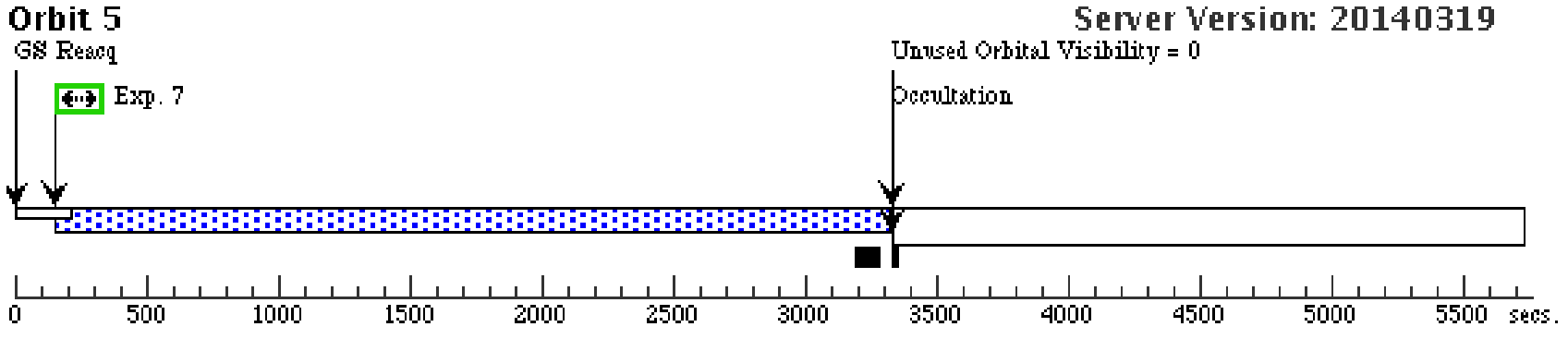
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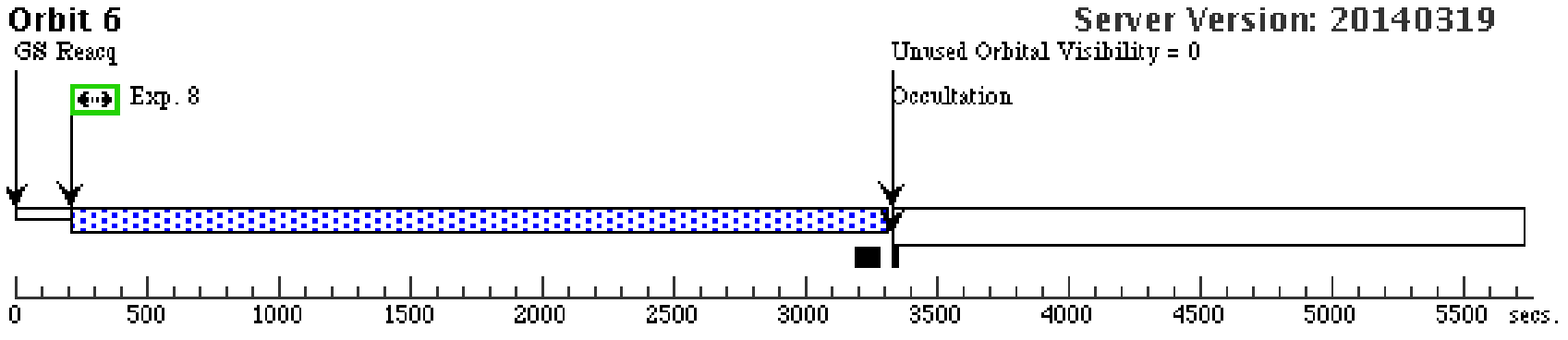
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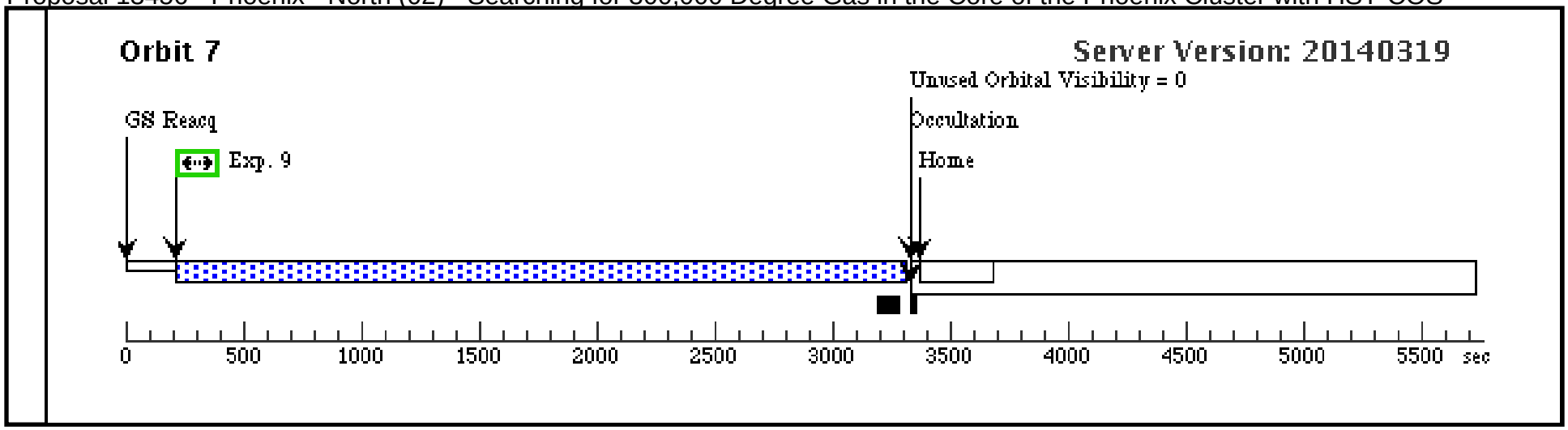
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## Visit

**Proposal 13456, Phoenix - Northwest (52), implementation** Thu May 15 20:01:08 GMT 2014

**Diagnostic Status: Warning**

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

## Diagnostics

(Phoenix - Northwest (52)) Warning (Orbit Planner): INEFFICIENT ORDERING OF FP-POS POSITIONS

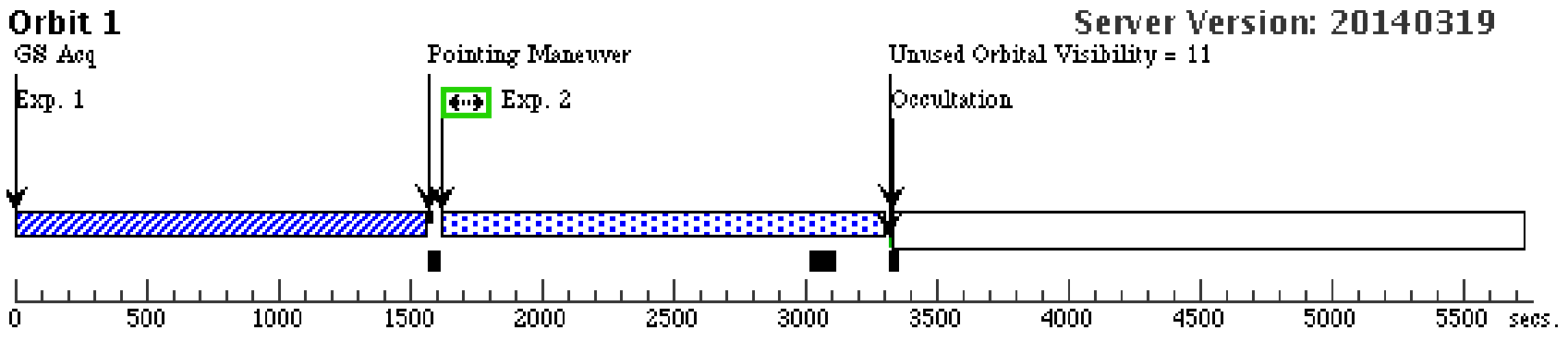
## Fixed Targets

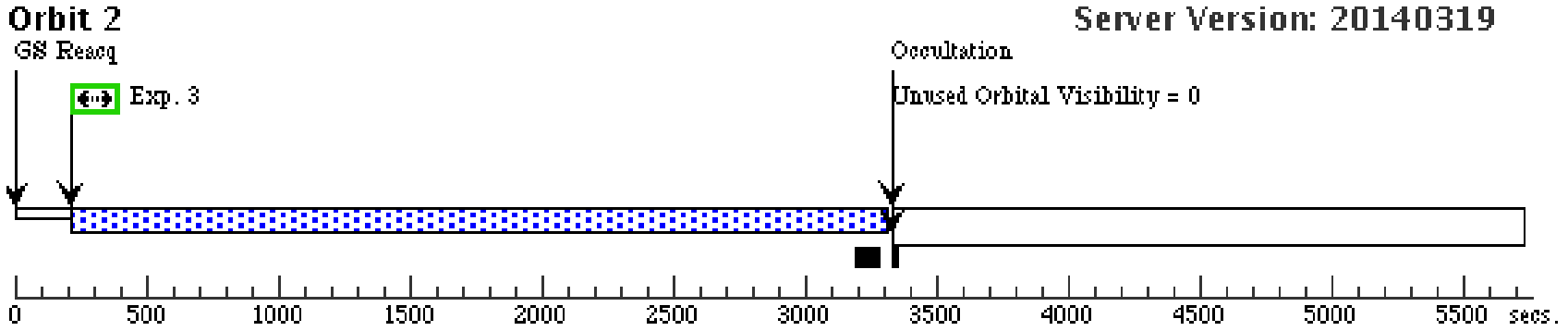
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (2) | PHOENIX-CENTER | RA: 23 44 43.8930 (356.1828875d)<br>Dec: -42 43 12.58 (-42.72016d)<br>Equinox: J2000 | | V=18.0 | Reference Frame: ICRS |
| *Comments: Center of galaxy, to be used for COS centroiding* | | | | | |
| (3) | PHOENIX-NW | Offset from PHOENIX-CENTER<br>RA Offset: -0.031 Secs<br>Dec Offset: 1.43 Arcsec | | V=18.0 | Offset Position (PHOENIX-NW) |

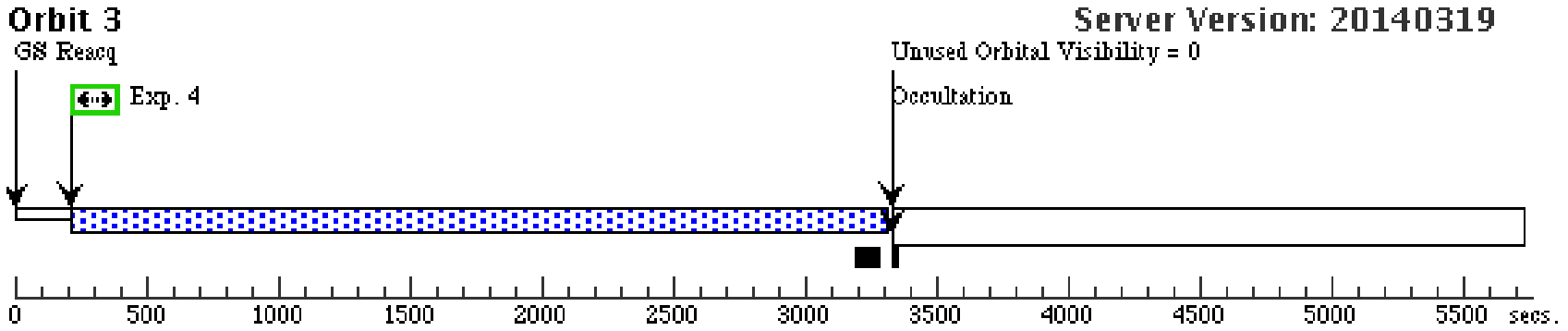
**Exposures**

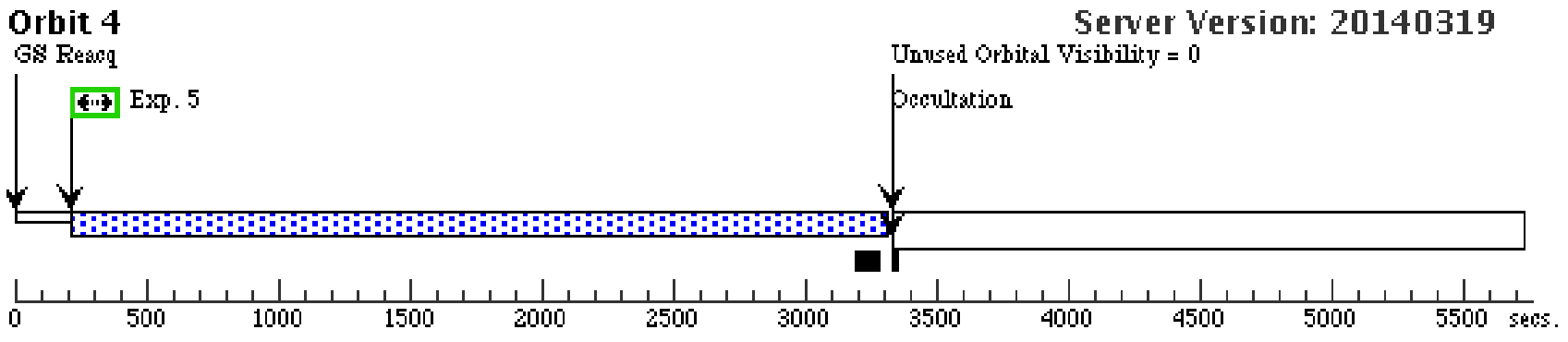
| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Phoenix A acquisition (COS.ta.510181) | (2) PHOENIX-CENTER | COS/NUV, ACQ/IMAGE, PSA | MIRRORA | | | | 580 Secs (580 Secs)<br>*[==>]* | *[1]* |
| 2 | (COS.sp.510045) | (3) PHOENIX-NW | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=1204; FLASH=YES; FP-POS=1; EXTENDED=YES | | | 1469 Secs (1469 Secs)<br>*[==>]* | *[1]* |
| 3 | (COS.sp.510045) | (3) PHOENIX-NW | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=2; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[2]* |
| 4 | (COS.sp.510045) | (3) PHOENIX-NW | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=3; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[3]* |
| 5 | (COS.sp.510045) | (3) PHOENIX-NW | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=4; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[4]* |
| 6 | (COS.sp.510045) | (3) PHOENIX-NW | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=2; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[5]* |
| 7 | (COS.sp.510045) | (3) PHOENIX-NW | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=3; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[6]* |
| 8 | (COS.sp.510045) | (3) PHOENIX-NW | COS/FUV, TIME-TAG, PSA | G160M 1577 A | BUFFER-TIME=2937; FLASH=YES; FP-POS=4; EXTENDED=YES | SAME POS AS 2 | | 3047 Secs (3047 Secs)<br>*[==>]* | *[7]* |

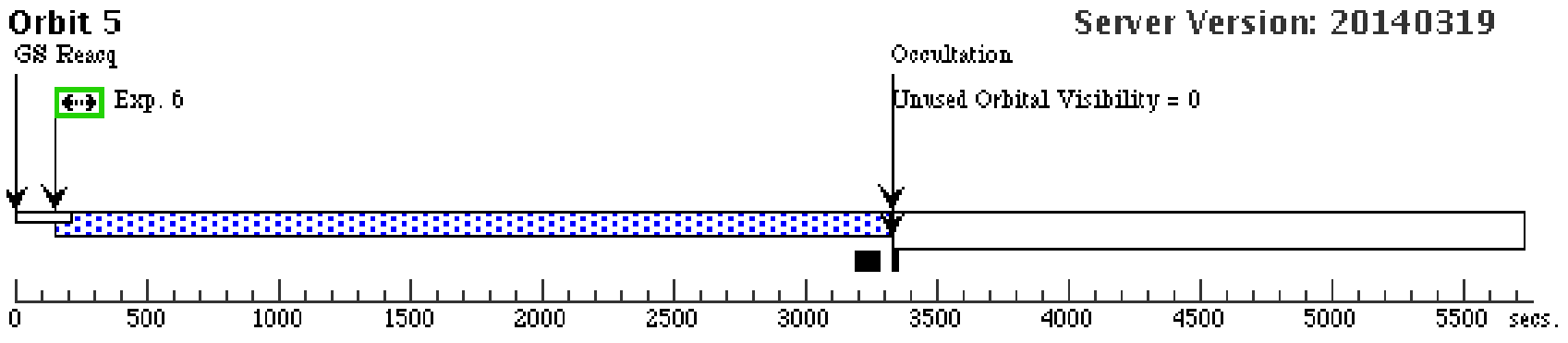
Orbit Structure

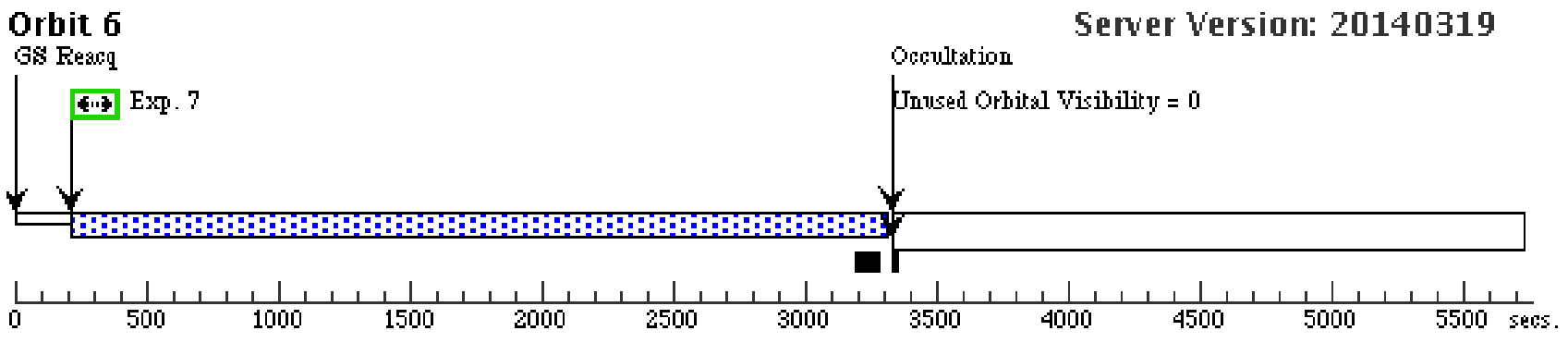


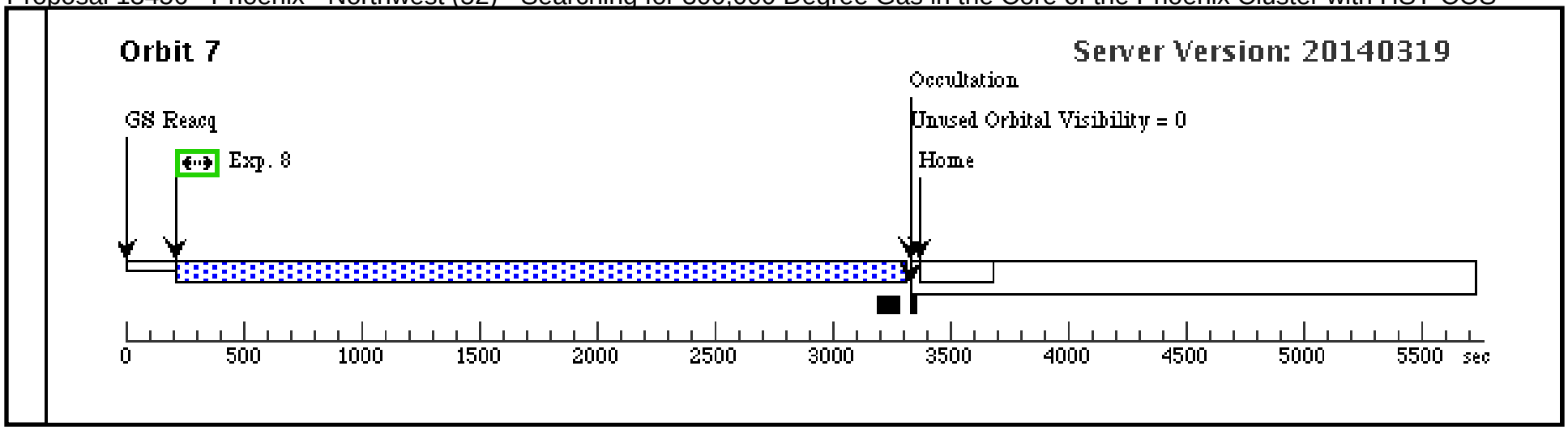




Orbit 4
Server Version: 20140319
GS Reacq
Unused Orbital Visibility = 0
Exp. 5
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 5
Server Version: 20140319
GS Reacq
Occultation
Exp. 6
Unused Orbital Visibility = 0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 6
Server Version: 20140319
GS Reacq
Occultation
Exp. 7
Unused Orbital Visibility = 0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 7
Server Version: 20140319
Occultation
GS Reacq
Unused Orbital Visibility = 0
Exp. 8
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec