# 14630 - A unique probe of the dark matter distribution in a halo at z=1: A strong lens with a bright central image

Cycle: 24, 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) DESJ2011-5228 | WFC3/IR<br>WFC3/UVIS | 3 | 09-Nov-2016 11:27:34.0 | yes |
| 02 | (1) DESJ2011-5228 | WFC3/UVIS | 3 | 09-Nov-2016 11:27:36.0 | yes |

6 Total Orbits Used

**ABSTRACT**

Cosmological dark matter simulations predict that the central regions of halos have 1/r density cusps. Baryonic processes and dark matter microphysics may resculpt these dark matter cusps, but these process are poorly understood and only weakly constrained by observations of a few low redshift halos.

We have discovered a strong lensing cluster at redshift 1 that includes a bright central image like no other: the central image is resolved! This makes for a uniquely powerful probe of the central regions of a dark matter halo without the need for additional dynamical constraints. An NFW halo cannot reconstruct the data: modelling of our DECam imaging with a double powerlaw density profile shows that the central slope must be much shallower than 1/r over at least the central 35 kpc.

We propose to obtain high resolution imaging of this lens with WFC3. This data will be able to conclusively distinguish between a large core and an even larger shallow cusp. It will be the first such measurement at z = 1 and the most precise measurement of the central DM profile of a cluster ever made. The data will also allow for an investigation of dark matter substructures at z=1. When combined with cosmological hydrodynamical simulations these results will place new constraints on the range of baryonic processes and DM microphysics that can flatten the central density profiles of cluster DM halos over kiloparsec scales.

**OBSERVING DESCRIPTION**

We require high resolution imaging of the target in F475W, F606W, F125W and F140W.

The required signal-to-noise is achieved with 3 orbits of 606, 2 orbits of 475 and 1 orbit split between 125 and 140.

Since resolution is key to our project,  we will use 4 dithers in each band to optimally sample the psf.

Our target is ~30 arcseconds in diameter and signal-to-noise across the whole target is important. We therefore centre the target on the center of a single UVIS chip: this avoids the target falling on the chip gap. We centre the IR chip on the center of our target.

In order to maximise the field of view around the target, we centre the UVIS exposures on chip 1 for the first visit, and chip 2 for the second visit. We offset the second visit by 2 arcseconds so that the full dataset covers the chip gap.

Our proposed observations are therefore:

Two visits of 3 orbits.

First visit: Apperture = UVIS1, and IR
Orbit 1: WFC3-UVIS:  Dither 1 (F606 then F475), Dither 2 (F606,F475)
Orbit 2: WFC3-UVIS:  Dither 3 (F606,F475), Dither 4 (F606,F475)
Orbit 3: WFC3-IR: Dither 1 (F125,F140), Dither 2 (F125,F140), Dither 3 (F125,F140), Dither 4 (F125,F140)

Second visit (alligned with first visit): Apperture = UVIS2, with a small offset to cover the chip gap.
Orbit 1: WFC3-UVIS:  Dither 1 (F606), Dither 2 (F606), Dither 3 (F606), Dither 4 (F606)
Orbit 2: WFC3-UVIS:  Dither 1 (F606,F475), Dither 2 (F606,F475)
Orbit 3: WFC3-UVIS:  Dither 3 (F606,F475), Dither 4 (F606,F475)

## Visit

**Proposal 14630, Visit 01, implementation**

Wed Nov 09 16:27:37 GMT 2016

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: (none)

## 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=false | | (1-2) |
| (2) | Pattern Type=WFC3-IR-DITHER-BOX-MIN<br>Purpose=DITHER<br>Number Of Points=4<br>Point Spacing=0.572<br>Line Spacing=0.365 | Coordinate Frame=POS-TARG<br>Pattern Orientation=18.528<br>Angle Between Sides=74.653<br>Center Pattern=false | | (3-4) |

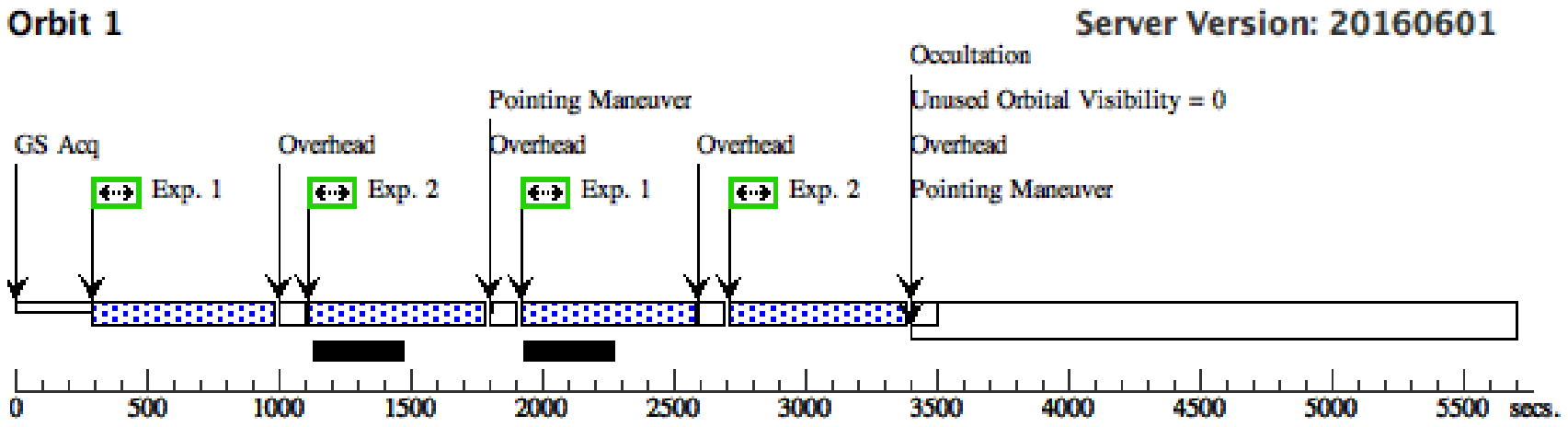
## Fixed Targets

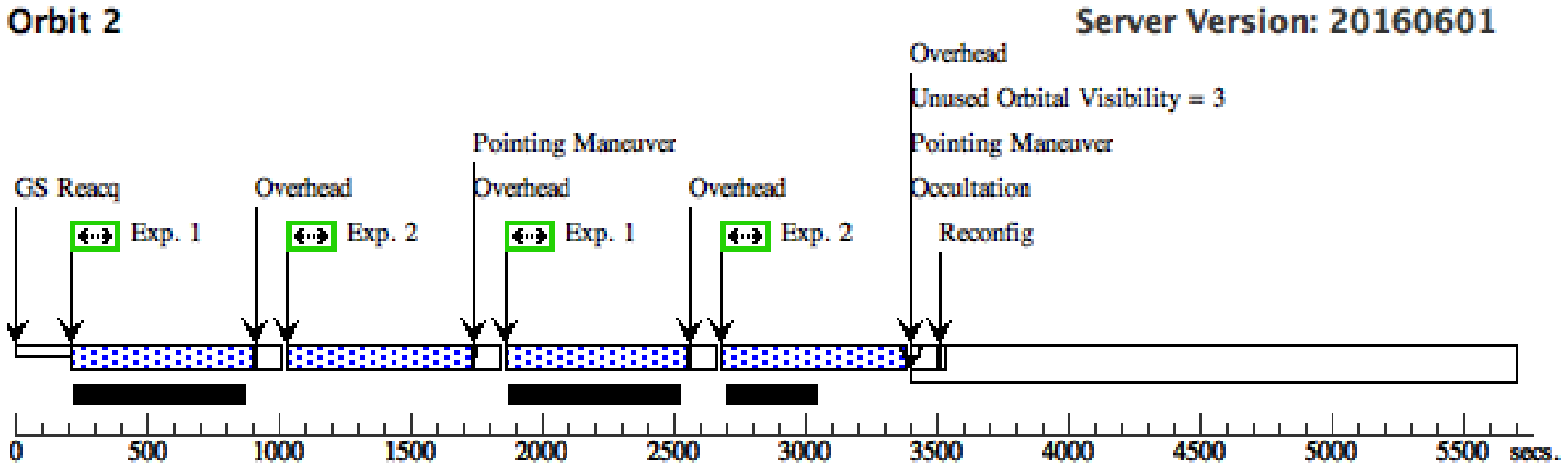
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | DESJ2011-5228 | RA: 20 11 7.0000 (302.7791667d)<br>Dec: -52 28 16.00 (-52.47111d)<br>Equinox: J2000 | | V=24 | Reference Frame: DES |

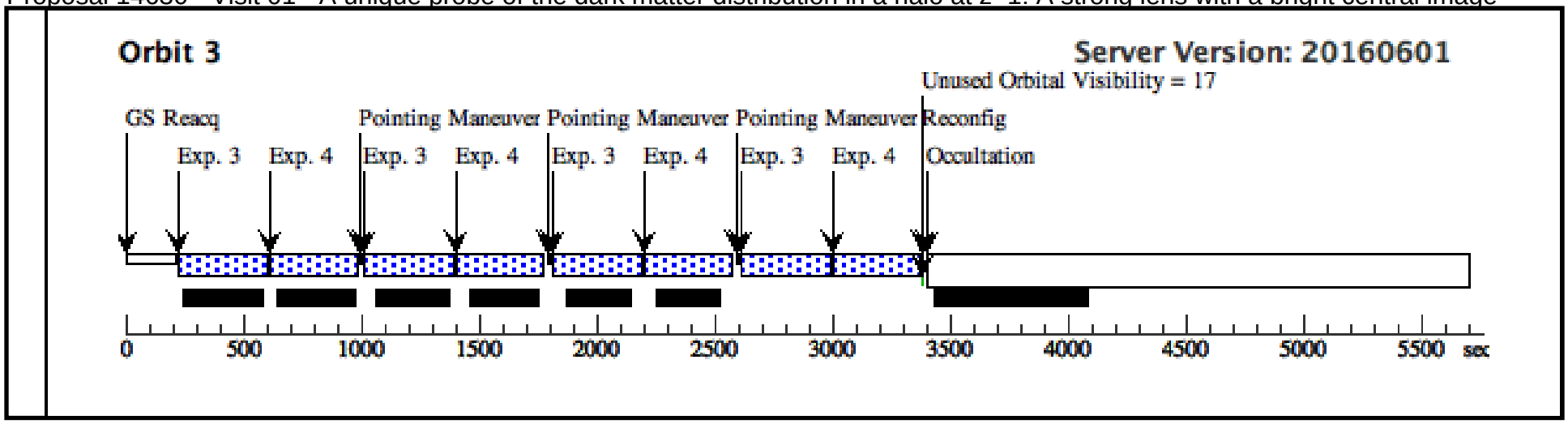
## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (1) DESJ2011-5228 | WFC3/UVIS, ACCUM, UVIS1 | F475W | | POS TARG null,-1 | Pattern 1, Exps 1-2 in Visit 01 (1) | 600 Secs (2690 Secs) | |
| | | | | | | | | *[==>659.0 Secs (Pattern 1)]*<br>*[==>659.0 Secs (Pattern 2)]* | ***[1]*** |
| | | | | | | | | *[==>686.0 Secs (Pattern 3)]*<br>*[==>686.0 Secs (Pattern 4)]* | ***[2]*** |
| 2 | | (1) DESJ2011-5228 | WFC3/UVIS, ACCUM, UVIS1 | F606W | | POS TARG null,-1 | Pattern 1, Exps 1-2 in Visit 01 (1) | 600 Secs (2690 Secs) | |
| | | | | | | | | *[==>659.0 Secs (Pattern 1)]*<br>*[==>659.0 Secs (Pattern 2)]* | ***[1]*** |
| | | | | | | | | *[==>686.0 Secs (Pattern 3)]*<br>*[==>686.0 Secs (Pattern 4)]* | ***[2]*** |
| 3 | | (1) DESJ2011-5228 | WFC3/IR, MULTIACCUM, IR | F125W | NSAMP=12;<br>SAMP-SEQ=STEP50 | | Pattern 2, Exps 3-4 in Visit 01 (2) | 349.232932 Secs (1396.932 Secs) | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | ***[3]*** |
| 4 | | (1) DESJ2011-5228 | WFC3/IR, MULTIACCUM, IR | F140W | NSAMP=12;<br>SAMP-SEQ=STEP50 | | Pattern 2, Exps 3-4 in Visit 01 (2) | 349.232932 Secs (1396.932 Secs) | |
| | | | | | | | | *[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | ***[3]*** |

Orbit Structure

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Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Reconfig
Exp. 3
Exp. 4
Exp. 3
Exp. 4
Exp. 3
Exp. 4
Exp. 3
Exp. 4
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

## Visit

**Proposal 14630, Visit 02, implementation** Wed Nov 09 16:27:37 GMT 2016

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/UVIS

Special Requirements: SAME ORIENT AS 01

## 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=false | | (1), (2-3) |

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| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
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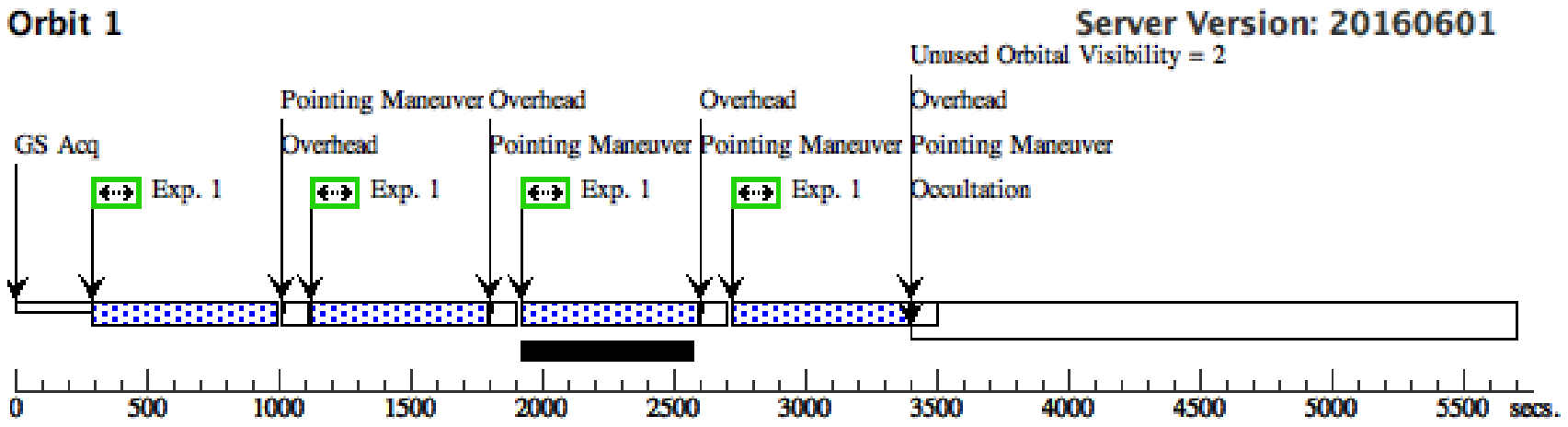
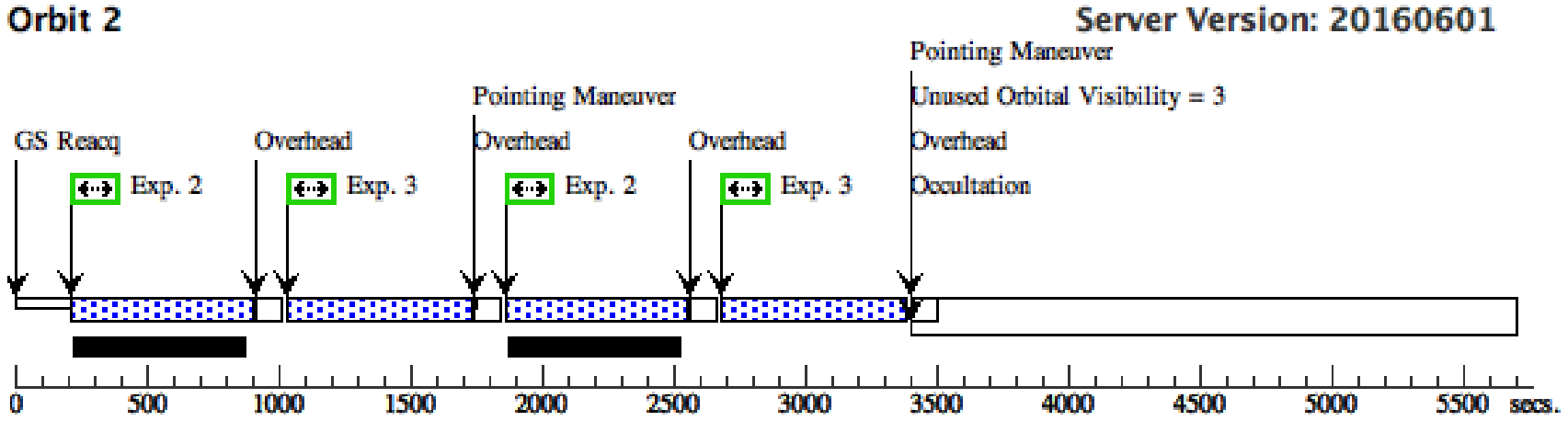
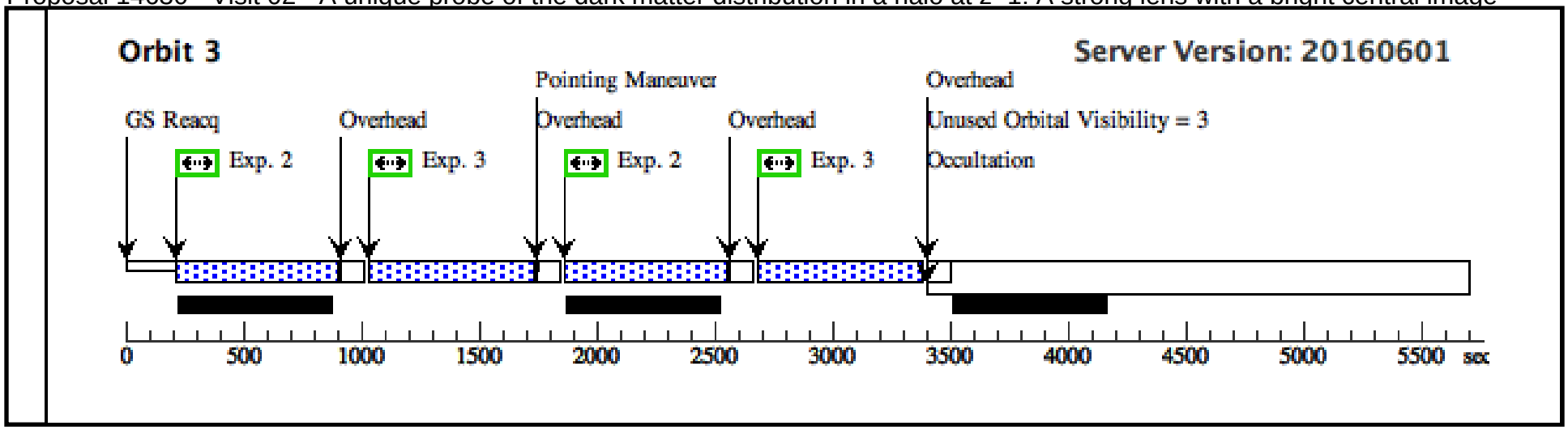
## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (1) DESJ2011-5228 | WFC3/UVIS, ACCUM, UVIS2 | F606W | | POS TARG null,1 | Pattern 1, Exps 1-1 in Visit 02 (1) | 600 Secs (2676 Secs) | |
| | | | | | | | | *[==>669.0 Secs (Pattern 1)]*<br>*[==>669.0 Secs (Pattern 2)]*<br>*[==>669.0 Secs (Pattern 3)]*<br>*[==>669.0 Secs (Pattern 4)]* | ***[1]*** |
| 2 | | (1) DESJ2011-5228 | WFC3/UVIS, ACCUM, UVIS2 | F475W | | POS TARG null,1 | Pattern 1, Exps 2-3 in Visit 02 (1) | 600 Secs (2744 Secs) | |
| | | | | | | | | *[==>686.0 Secs (Pattern 1)]*<br>*[==>686.0 Secs (Pattern 2)]* | ***[2]*** |
| | | | | | | | | *[==>686.0 Secs (Pattern 3)]*<br>*[==>686.0 Secs (Pattern 4)]* | ***[3]*** |
| 3 | | (1) DESJ2011-5228 | WFC3/UVIS, ACCUM, UVIS2 | F606W | | POS TARG null,1 | Pattern 1, Exps 2-3 in Visit 02 (1) | 600 Secs (2744 Secs) | |
| | | | | | | | | *[==>686.0 Secs (Pattern 1)]*<br>*[==>686.0 Secs (Pattern 2)]* | ***[2]*** |
| | | | | | | | | *[==>686.0 Secs (Pattern 3)]*<br>*[==>686.0 Secs (Pattern 4)]* | ***[3]*** |

Orbit Structure




Orbit 3
Server Version: 20160601
GS Reacq
Overhead
Pointing Maneuver
Overhead
Overhead
Overhead
Unused Orbital Visibility = 3
Exp. 2
Exp. 3
Exp. 2
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
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4000
4500
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sec