17601 - The first changing-multiplicity lensed quasar: a probe of sub-parsec quasar structure at Cosmic Noon

Cycle: 31, 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) PSJ2107-1611	WFC3/IR WFC3/UVIS	2	18-Jun-2024 19:01:12.0	yes
51	(1) PSJ2107-1611	WFC3/IR WFC3/UVIS	2	18-Jun-2024 19:01:13.0	yes

4 Total Orbits Used

ABSTRACT

A standard scheme for quasar structure has been built up over the last 60 years, comprising a supermassive black hole, accretion disk, torus, and broad and narrow line regions. Constraining these regions' kinematics and geometry remains difficult, particularly at high redshift, where all studies are unresolved. A recent discovery of a quadruply imaged lensed quasar has opened up an unprecedented and exciting probe of the subparsec-scale geometry of a quasar at z=2.7. The system shows 4 point sources in the optical (to 0.93 microns), yet only two point sources in recent JWST-MIRI imaging (5.6 microns), and follow-up ERIS-NIX Ks imaging (2.1 microns). This is entirely unexpected since lensing is achromatic, but could be explained by the source lying within a parsec of the region that splits the 4- and 2-image regimes. However, there are still several unanswered questions. How is the rest-frame UV of the accretion disk imaged four times, yet its optical emission is not? How can parts of the broad line region be imaged four times, yet the torus, thought to be larger, is not. High-resolution optical imaging is necessary to answer these questions: HST multi-band imaging will resolve the close optical image pair, and constrain a precise mass model from the lensed host galaxy arcs. Such a model will map the various optical quasar components back to the source at sub-parsec resolution, and fully exploit the existing JWST-MIRI, MUSE and ERIS datasets. Finally we will constrain the disappearance of the image pair to a narrow wavelength range, disambiguating several plausible explanations, e.g., an asymmetric torus, a second UV continuum source, or alternative dark matter models.

OBSERVING DESCRIPTION

We propose to use HST's Wide Field Camera 3 (WFC3) for deep, high-resolution imaging in the optical and near-infrared.
We plan observations in three filters to provide a comprehensive view and understanding of the system.
Specifically, we describe the reason for each filter below:
- F475X: this band will provide the first ever view of image A, confirming our suspicion that this is a nearby merging pair. The bright Lya emission in the host galaxy would fall within this filter, providing an Einstein ring to constrain the lens model and map the host galaxy Lya emission,
- F814W: a second optical filter where we know the images exist will allow comparison to F475X, and detect any astrometric change and thus a possible second spatially separated source of UV continuum emission. Furthermore, the host galaxy will again be lensed into a bright arc of about 21 i-mag/arcsec2 (F814W), and can be revealed with high SNR,
- F160W: this filter covers a yet completely uncharted wavelength range, that of the disappearing image. If the images are seen, we can again compare the point source

pair's astrometry to the optical positions and confirm the presence of any spatially separated rest-frame optical emission region. If the images are not seen, this will put strong constraints on the non-AGN continuum emitter and its position.

These filter/instrument combinations match closely those of previous lensed quasar proposals (e.g., proposals 14254, 15320, and 17199), and would add to a homogeneous dataset for future studies of collections of quadruply imaged lensed quasars.

Dithering pattern and exposure times: In F475X and F814W, we care about sampling the PSF as well as possible, and centroiding/separating two nearby PSFs to within milliarsecond precision. We choose to perform 4 dithers in each band, consisting of two short and two long exposures to avoid saturating the bright quasar images, with a total exposure time of 1600s. Given previous WFC3-UVIS exposure times on lensed quasars of similar brightness, such an astrometric precision can be achieved.

With the WFC3/IR detector we will use a four-point dither pattern, with the standard multiple-readout sampling (MULTIACCUM mode). We will use STEP50 exposure sequences which will provide 6-8 samples in the brightest regions of the quasar images and will allow parallel buffer dumps to minimize overheads. Persistence will occur at the locations of the quasar images, and we will therefore ensure that our dithering pattern does not place our target on affected pixels. This configuration will efficiently reject cosmic rays and hot pixels, improve the sampling of the PSF of the drizzled images, and properly sample the full dynamical range of these high-contrast data. While the SNR in the arc will be high (up to 20 per pixel), we do not know the brightness of the close image pair (or even if they will exist at the wavelength of F160W). A total exposure time of 2200s will allow for the detection of very faint PSFs (22.2 Vega-mag, 5 sigma point source), and allow for a sufficient dynamic range to expose both the bright quasar images (B and C) and the host galaxy/faint PSF pair.

Visit

Proposal 17601, Visit 01, failed Tue Jun 18 23:01:14 GMT 2024

Diagnostic Status: Warning

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: (none)

Diagnostics

(Visit 01) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Visit 01) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=WFC3-IR-DITHER-LINE Purpose=DITHER Number Of Points=4 Point Spacing=1.56 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=41.788 Angle Between Sides= Center Pattern=false		(9)

Fixed Targets

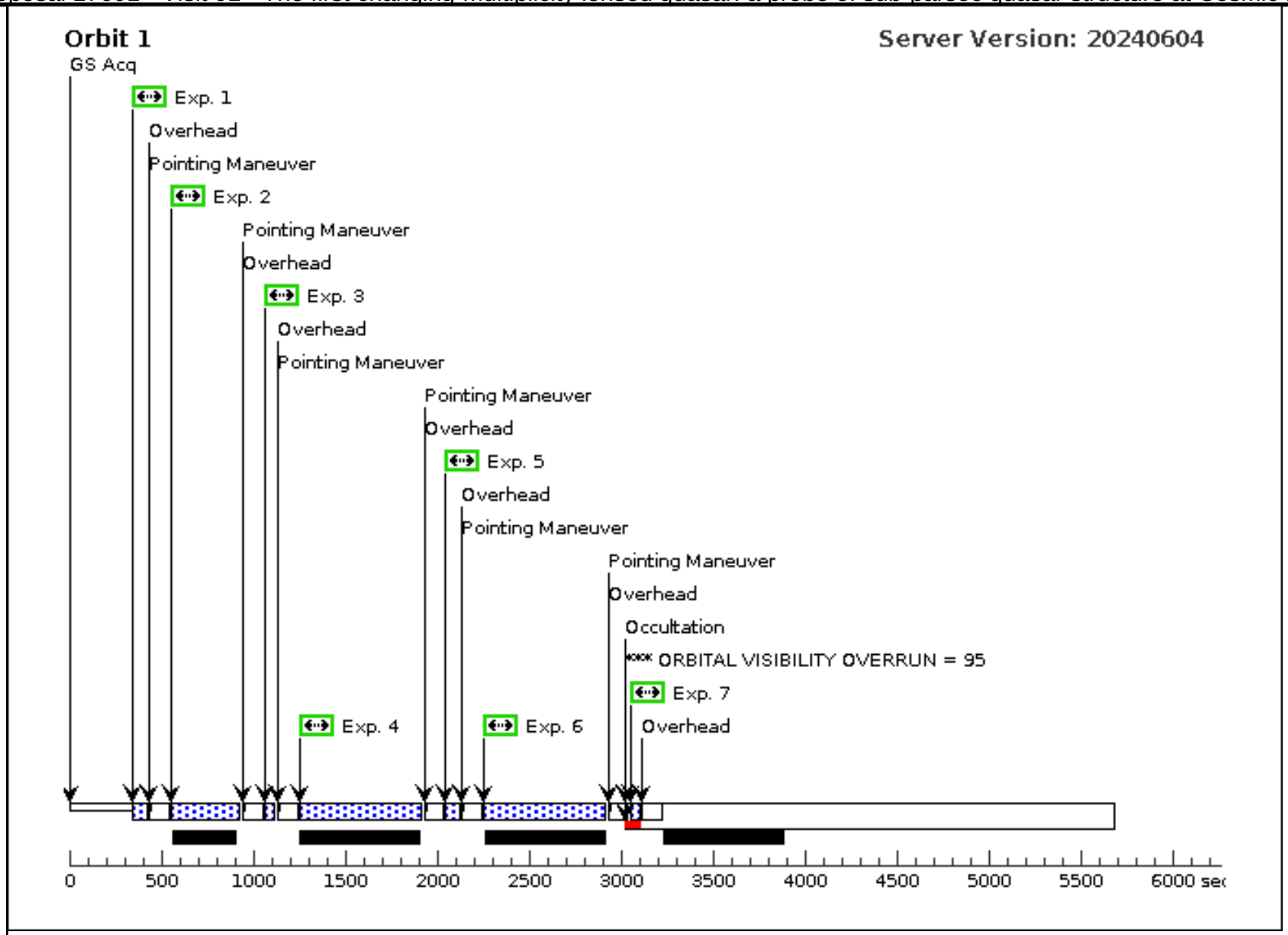
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PSJ2107-1611	RA: 21 07 52.4400 (316.9685000d) Dec: -16 11 32.28 (-16.19230d) Equinox: J2000		V=19.5+/-0.5	Reference Frame: ICRS

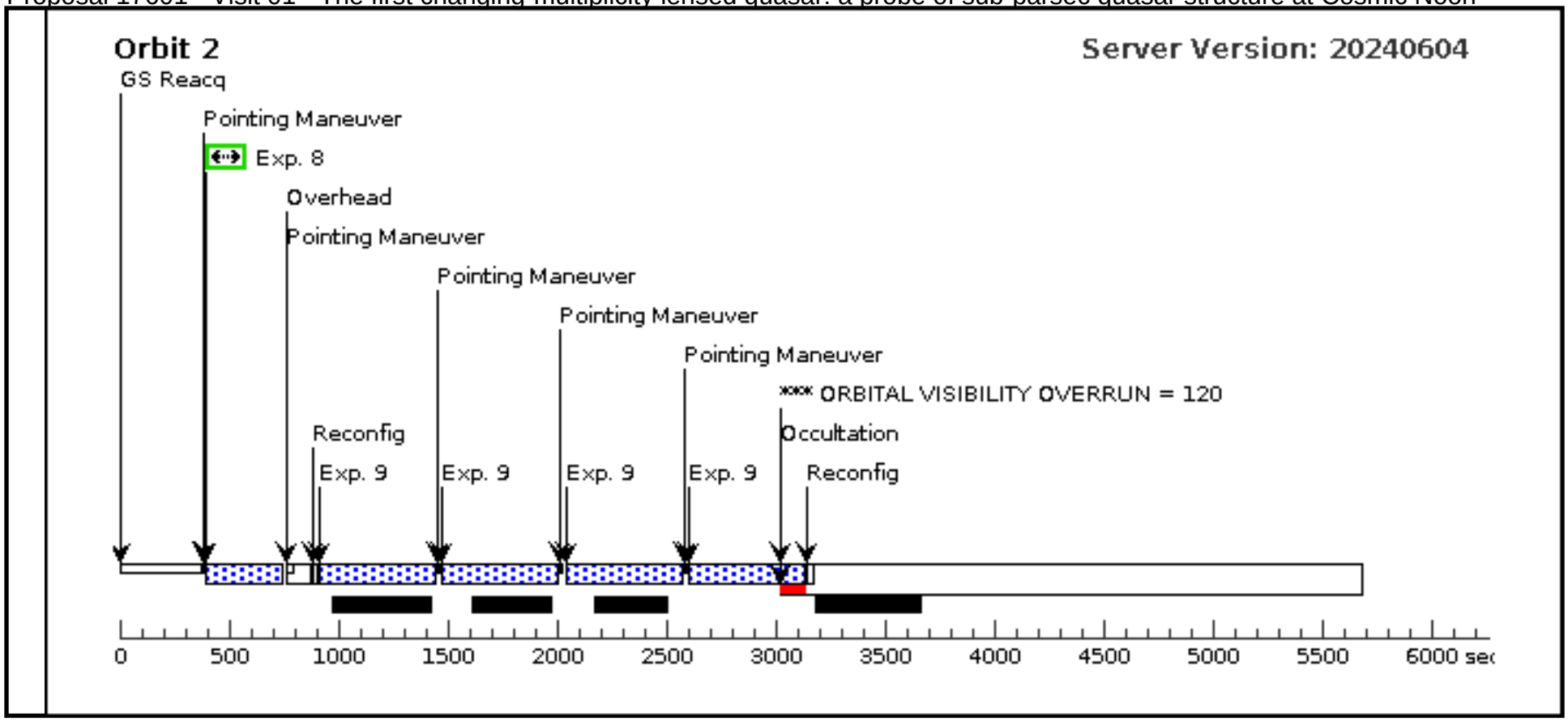
Comments:
Category=GALAXY
Description=[GRAVITATIONAL LENS, QSO, QUASAR]

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	F475X short 1 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X	FLASH=21	POS TARG 0,0		50 Secs (50 Secs) *[==>]*	*[1]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
2	F475X medium (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X	FLASH=6	POS TARG 0.158,0.070		375 Secs (375 Secs) *[==>]*	*[1]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
3	F475X short 2 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X	FLASH=21	POS TARG 0.099,0.165		50 Secs (50 Secs) *[==>]*	*[1]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
4	F475X long (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X		POS TARG -0.060,0.095		666. Secs (666 Secs) *[==>]*	*[1]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
5	F814W short 1 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=21	POS TARG 0,0		50 Secs (50 Secs) *[==>]*	*[1]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
6	F814W long (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=2	POS TARG 0.158,0.070		666 Secs (666 Secs) *[==>]*	*[1]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
7	F814W short 2 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=21	POS TARG 0.099,0.165		50 Secs (50 Secs) *[==>]*	*[1]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
8	F814W medium (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=9	POS TARG -0.060,0.095		355 Secs (355 Secs) *[==>]*	*[2]*
	Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/								
9	F160W	(1) PSJ2107-1611	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP50; NSAMP=15		Pattern 2, Exps 9-9 in Visit 01 (2)	499.234285 Secs (1996.937 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	*[2]*

Orbit Structure

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Server Version: 20240604
GS Reacq
Pointing Maneuver
Exp. 8
Overhead
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
**** ORBITAL VISIBILITY OVERRUN = 120
Occultation
Reconfig
Exp. 9
Exp. 9
Exp. 9
Exp. 9
Reconfig
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec

Visit

Proposal 17601, Visit 51, pi Tue Jun 18 23:01:14 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: (none)

Comments: Duplicate of visit 01 after gyro failure.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=WFC3-IR-DITHER-LINE Purpose=DITHER Number Of Points=4 Point Spacing=1.56 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=41.788 Angle Between Sides= Center Pattern=false		(9)

Fixed Targets

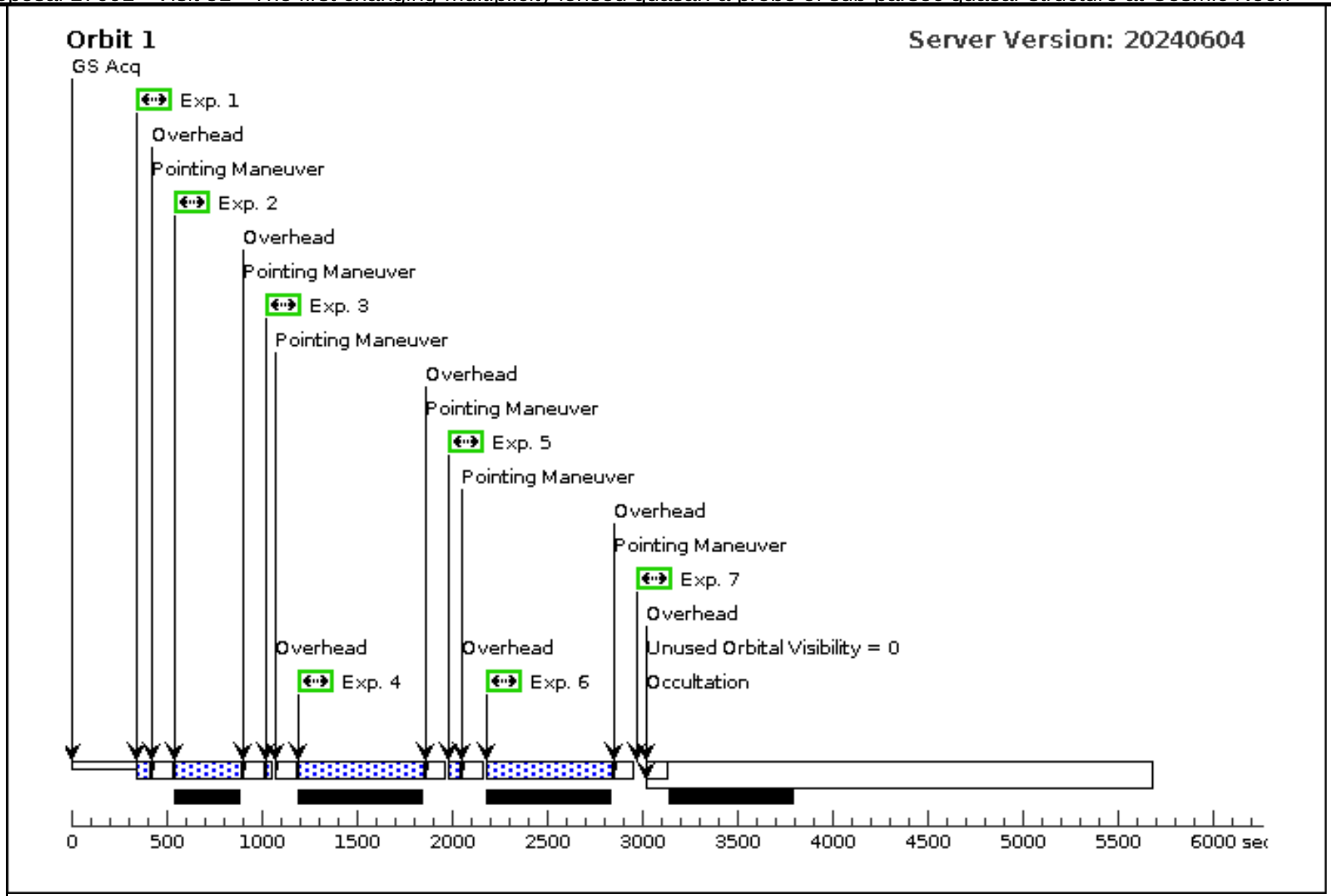
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PSJ2107-1611	RA: 21 07 52.4400 (316.9685000d) Dec: -16 11 32.28 (-16.19230d) Equinox: J2000		V=19.5+/-0.5	Reference Frame: ICRS

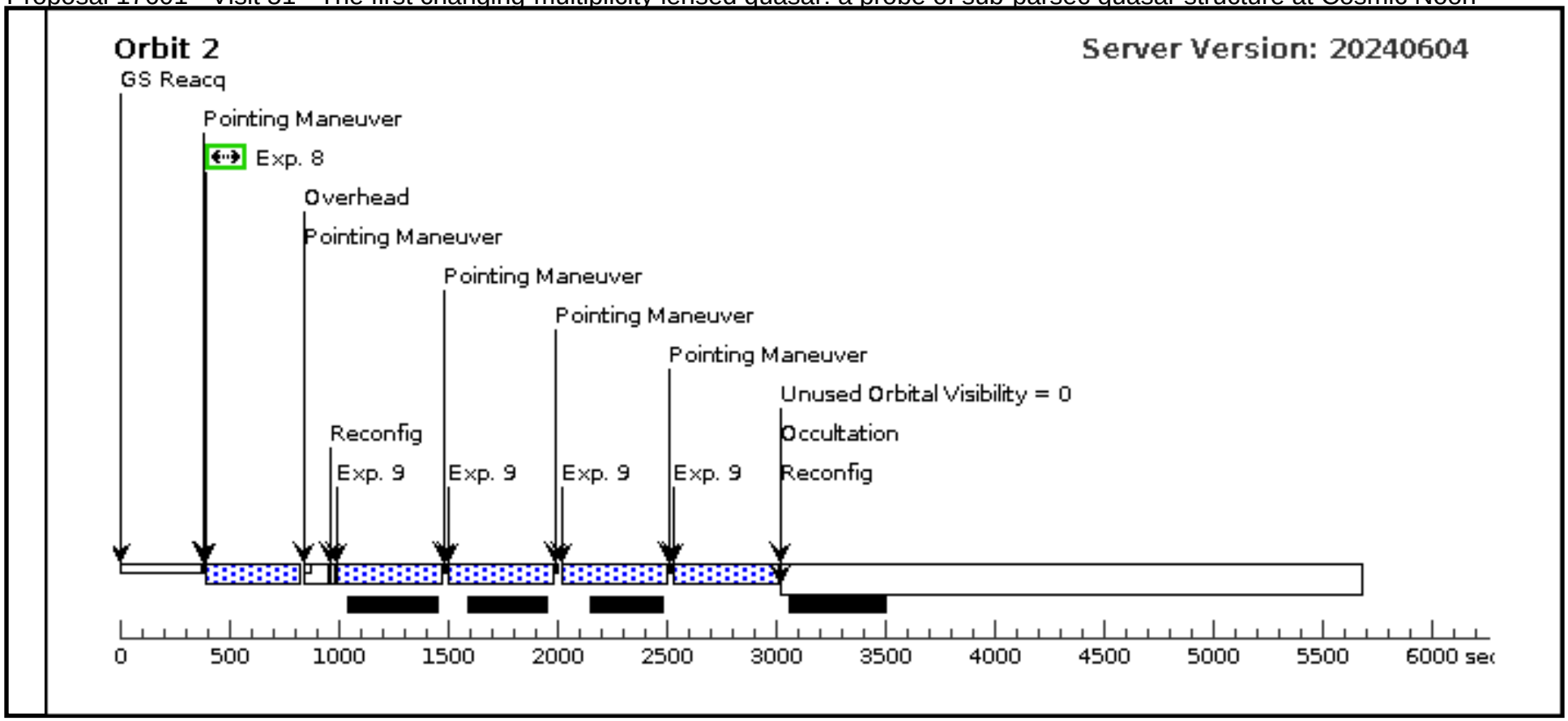
Comments:
Category=GALAXY
Description=[GRAVITATIONAL LENS, QSO, QUASAR]

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	F475X short 1 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X	FLASH=21	POS TARG 0,0		50 Secs (34 Secs) *[==>34.0 Secs]*	***[1]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
2	F475X medium (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X	FLASH=6	POS TARG 0.158,0.070		375 Secs (348 Secs) *[==>348.0 Secs]*	***[1]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
3	F475X short 2 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X	FLASH=21	POS TARG 0.099,0.165		50 Secs (34 Secs) *[==>34.0 Secs]*	***[1]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
4	F475X long (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F475X		POS TARG -0.060,0.095		666. Secs (664 Secs) *[==>664.0 Secs]*	***[1]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
5	F814W short 1 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=21	POS TARG 0,0		50 Secs (34 Secs) *[==>34.0 Secs]*	***[1]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
6	F814W long (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=2	POS TARG 0.158,0.070		666 Secs (664 Secs) *[==>664.0 Secs]*	***[1]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
7	F814W short 2 (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=21	POS TARG 0.099,0.165		50 Secs (34 Secs) *[==>34.0 Secs]*	***[1]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
8	F814W medium (1900877)	(1) PSJ2107-1611	WFC3/UVIS, ACCUM, UVIS2	F814W	FLASH=9	POS TARG -0.060,0.095		355 Secs (435 Secs) *[==>435.0 Secs]*	***[2]***
Comments: https://etc.stsci.edu/etc/results/WFC3UVIS.im.1900877/									
9	F160W	(1) PSJ2107-1611	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP50; NSAMP=14		Pattern 2, Exps 9-9 in Visit 51 (2)	449.233834 Secs (1796.935 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***

Orbit Structure




Orbit 2
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GS Reacq
Pointing Maneuver
Exp. 8
Overhead
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Orbital Visibility = 0
Occultation
Reconfig
Reconfig
Exp. 9
Exp. 9
Exp. 9
Exp. 9
0
500
1000
1500
2000
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3000
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4000
4500
5000
5500
6000 sec