15613 - The Astrophysics of the Most Energetic Gamma-Ray Bursts

Cycle: 26, 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) GRB-180720B	WFC3/UVIS	2	17-Sep-2018 18:00:17.0	yes
T1	(1) GRB-180720B	WFC3/UVIS	2	17-Sep-2018 18:00:19.0	yes
T2	(1) GRB-180720B	WFC3/UVIS	2	17-Sep-2018 18:00:20.0	yes
T3	(1) GRB-180720B	WFC3/UVIS	2	17-Sep-2018 18:00:21.0	yes
T5	(1) GRB-180720B	WFC3/UVIS	2	17-Sep-2018 18:00:22.0	yes

10 Total Orbits Used

ABSTRACT

The Fermi Large Area Telescope (LAT) has found a sample of highly relativistic gamma-ray bursts (GRBs), which may be among the most energetic bursts ever discovered. Here we propose to use Chandra and HST to follow the late time X-ray and optical light curves of a LAT detected burst that also has excellent early multiwavelength coverage. Our observations, in conjunction with the Fermi data, will allow us to measure the energy, bulk Lorentz factor, and in some cases probe the jet physics of the explosion. Recent work by us and others on some of the most powerful GRBs has begun to substantially constrain physical models of the progenitors. Our observations may greatly strengthen these constraints as well as provide new insight into the relativistic physics of the bursts.

OBSERVING DESCRIPTION

We propose to observe a LAT-detected burst with {\it Chandra}. We will
select a burst that has $\Eiso > 5 \times10^{53}\,$ erg (bolometric), as well as {\it Swift} XRT
and ground-based optical detections of the afterglow. As a luminosity distance is require to estimate $\Eiso$, the
requirement on $\Eiso$ means that we will only observe a burst with
a measured redshift. There is one exception to these requirements. In the rare instance that an ULGRB fulfills all of these conditions except for a LAT detection,
we will ask the Director for permission to trigger. We estimate that ULGRBs meeting our large $\Eiso$ requirement are on average detected only once per 5 -- 10 years.

Based
on the history of LAT bursts since the launch of {\it Fermi}, there is a $\sim 75\%$ chance that
a burst will meet our criteria during the next Cycle of
{\it Chandra}. We will take the first burst during the Cycle meeting our criteria
which has good ongoing
ground-based optical and {\it Swift} XRT observations. Our default strategy
is to have two or three visits with {\it Chandra}, depending on the behavior of the burst. We will use the

{\it Swift} data to estimate when the burst is likely
to reach a flux of $4 \times 10^{-14} \erg \cm^{-2} {\rm s}^{-1}$,
which is the effective limit of {\it Swift}, and will plan a first visit by
{\it Chandra} at a time 50\% later after the burst, assuming that the burst
will fall with a constant slope as the bursts in Figure 2. This visit
should occur between twenty-four and thirty days after burst. We
will therefore be asking for a trigger with a lead time of about two weeks. If {\it Swift} and ground-based optical data show an unambiguous break,
{\it Chandra} and {\it HST} observations would likely prove superfluous and
we will not trigger. If the break is marginal, we will trigger, as {\it Chandra} could clearly determine a break
and measure its size -- which is important for understanding the relativistic physics of the outflow.

The {\it Swift} XRT band is nearly identical to that of {\it Chandra} ACIS. We
estimate that at the first visit {\it Chandra} will detect approximately
$2.5\times 10^{-3}\,$ cps, assuming the burst continues to fall
approximately as $t^{-1.2}$. So in 25ks we will reach a SNR of about eight.
Should the burst break to t^{-2} we will obtain a SNR of
about four -- though this depends greatly on the luminosity of the burst and the depth to which {\it Swift} followed the burst. If the first visit
indicates a strong break has already occurred we will
use the remaining time for a single deep observation between 1.5 and 2 times
later than the first observation. However, it is unlikely we will get a strong signal of a break in the first visit without
an earlier indication from the ground. Therefore, we will more likely re-observe
at about 1.5 times later than the first {\it Swift} observation using about 40 ks
of time, reserving 55 ks for a final deep third epoch, for a total of 120 ks.
{\it We note that the point-source sensitivity required by our late-time observations can only be achieved by Chandra.}

Several co-Is of this proposal have direct access to optical/near-infrared follow-up facilities,
which
will enable rapid afterglow identification and redshift determination.
However after about two weeks, it is likely that the observations from the ground will become

insufficiently deep to follow the optical transient, even using the
time on eight to ten meter class telescopes. {\it HST} will allow us to continue to follow the optical
transient for several more weeks. We therefore ask for an {\it HST}
ToO. As prior Cycles show, the three-week notification for HST works for this project, as the
ground-based observations should typically get us reliable data points out to
two weeks, and we can typically accept a gap of two weeks after that before the {\it HST} observations.

We plan four visits with {\it HST}: the first an orbit long, a second two
orbits long, a third four orbits long and a fourth final visit also four
orbits long. Where possible the {\HST} observations will roughly coincide with the corresponding {\it Chandra} epochs. The exact times will be scaled according
to the decay seen from the ground and earlier {\it HST} observations. The first three visits will
be used to measure the decay slope of the light curve. The fourth visit will be taken at
least six months after the burst to allow an accurate host galaxy
subtraction.
We will use the UVIS camera on WFC3 because of its point source sensitivity
and low noise, and will
choose the filter at the time of the ToO to match one of the best
observed bands from the ground (most likely a red band). If, however,
the burst has a redshift $z < 1.25$, we will want to observe in a bluer
band to avoid possible supernova contamination. Our team's
past success in obtaining Gemini and VLT time makes it likely
we (as well as others) will be able to acquire the early ground-based observations necessary for us to trigger on a burst. As the spectral energy distribution of the afterglow is
also important for modelling the burst, if we do not have a good SED from the ground, we will use part of our time to image the transient in the IR, again using WFC3.

In this proposal, we also are asking for JVLA time to follow up to two bursts that meet our
trigger criteria. The JVLA observations will start shortly after the burst,

and it is possible (but not at all probable) that a burst that meets our trigger criteria could clearly break while it is still visible to {\it Swift}. If this happens we will not trigger {\it Chandra} or {\it HST}, but instead will wait for the next burst meeting our criteria. We will require three hours for each of the two bursts to allow this early follow up to determine if the burst is visible in the radio. We will break these early observations into 30 minute observations in C (4--8 GHz) and Ku (18--26 GHz) bands. While the Ku band is less sensitive, the GRB is expected to be brighter and interstellar scintillation less of an issue at higher frequencies, so using both bands can be valuable.

If a radio afterglow is well-detected ($f_{\nu} > 100$\,μJy), we will carry out more detailed observations. We will want to follow the evolution of the light curve sufficiently long to measure the jet break and to see the source fade as the synchrotron peak moves through the radio band. Experience shows that this will typically require another dozen epochs $\sim$1--100 days after the burst. Each epoch can be 30 min in duration. Our total request of JVLA time for the two bursts is therefore 18 hours. If an afterglow is still visible after $\sim$150 days it may be possible to use late-time JVLA observations to estimate the total energy of the burst (SB11) using the Sedov-Taylor approximation. If this method works to the accuracy hoped for, it could provide an independent check on the energies determined from the break observations, and thus on our understanding of the physics of the relativistic jet. In cases where this approach looks promising, we will submit a separate proposal to NRAO to follow any such events to very late times (years -- though in the case of GRB 130427A, which is a powerful burst in a tenuous medium, it may be more like a decade!

Visit

Proposal 15613, Visit 01 Mon Sep 17 22:00:23 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 65D TO 65 D

Patterns

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

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GRB-180720B	RA: 00 02 7.0729 (.5294704d) Dec: -02 56 5.68 (-2.93491d) Equinox: J2000		V=26	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[GAMMA RAY BURSTER]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F438W	FLASH=7	GS ACQ SCENARIO SINGLE	Pattern 1, Exps 1-2 in Visit 01 (1)	550 Secs (2200 Secs)	
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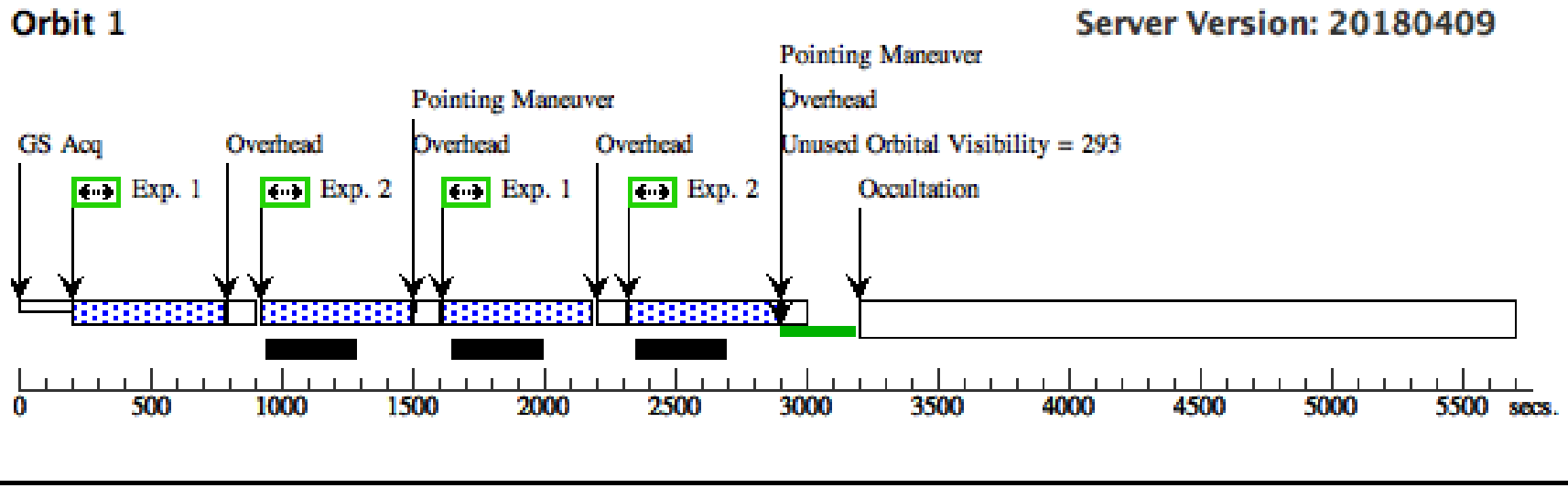
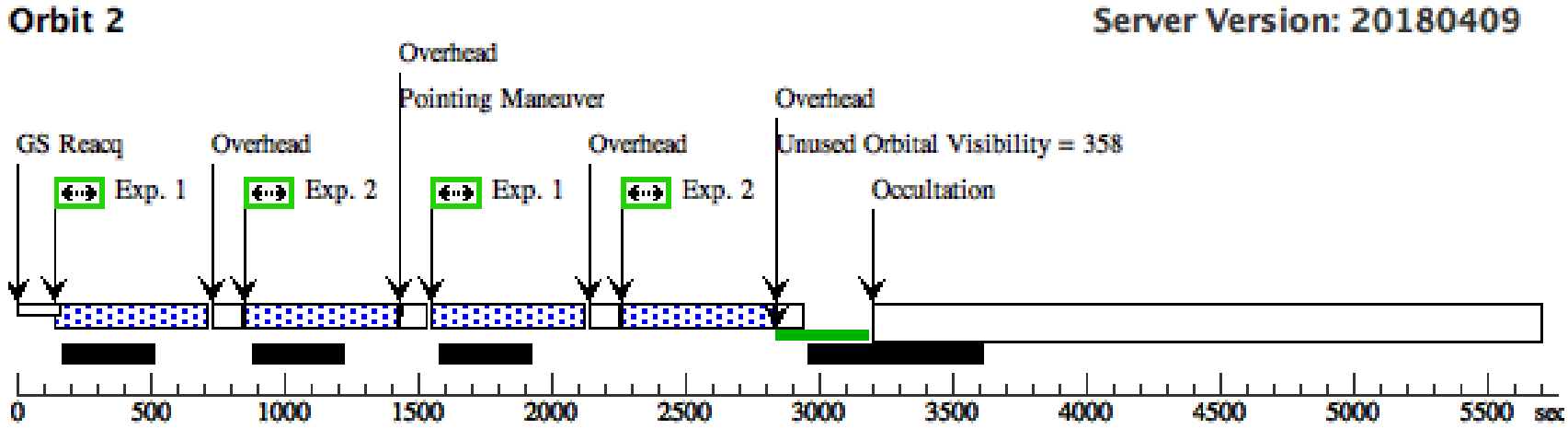
								[==>(Pattern 3)] *[==>(Pattern 4)]*	***[2]***
2		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F606W			Pattern 1, Exps 1-2 in Visit 01 (1)	550 Secs (2200 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***
								[==>(Pattern 3)] *[==>(Pattern 4)]*	***[2]***

Orbit Structure





Visit

Proposal 15613, Visit T1, implementation Mon Sep 17 22:00:23 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

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

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GRB-180720B	RA: 00 02 7.0729 (.5294704d) Dec: -02 56 5.68 (-2.93491d) Equinox: J2000		V=26	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[GAMMA RAY BURSTER]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F438W	FLASH=7	POS TARG -61.62995788269611,-3.9737750538771808; GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-2 in Visit T1 (1)	550 Secs (2200 Secs)	
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								[==>(Pattern 3)] *[==>(Pattern 4)]*	***[2]***
2		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F606W		POS TARG -61.62995788269611,-3.9737750538771808	Pattern 1, Exps 1-2 in Visit T1 (1)	550 Secs (2200 Secs)	
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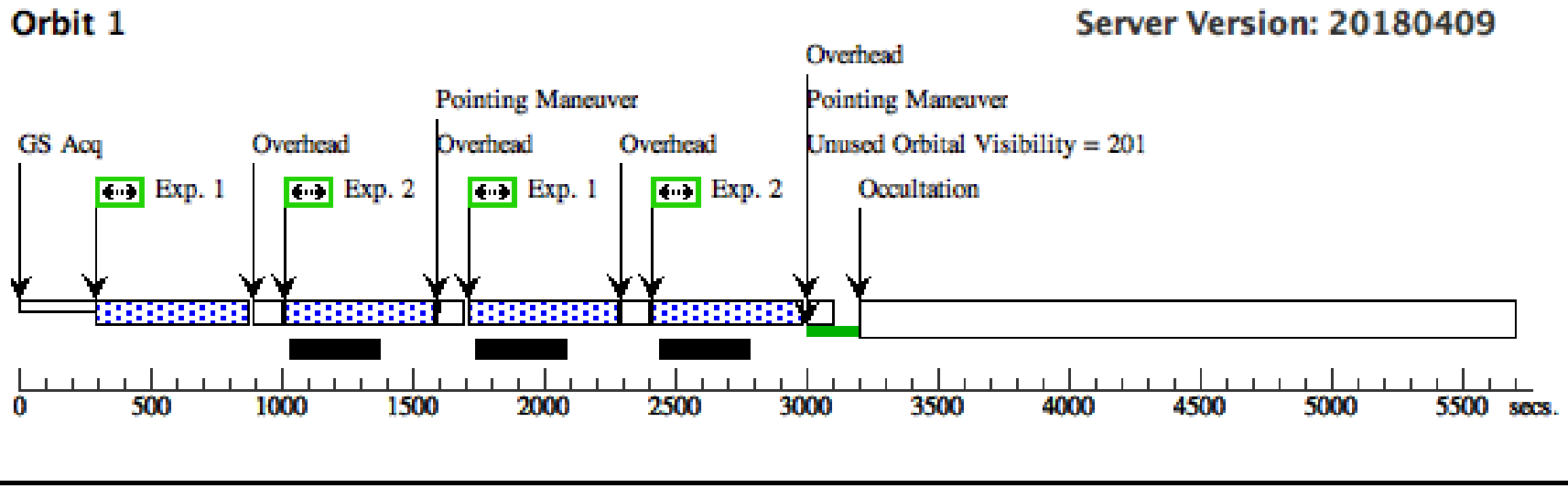
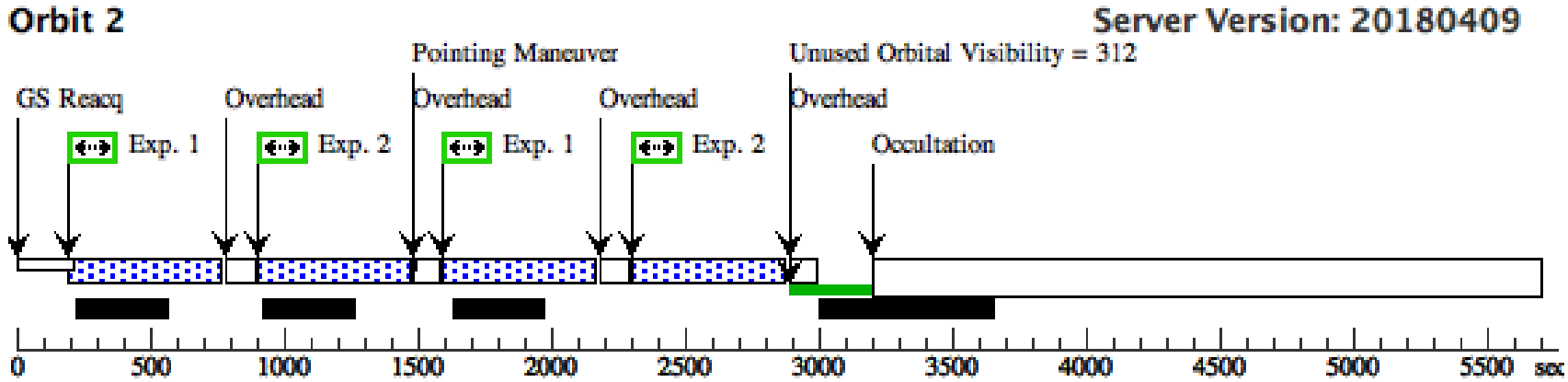
Orbit Structure





Visit

Proposal 15613, Visit T2, implementation Mon Sep 17 22:00:23 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

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

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GRB-180720B	RA: 00 02 7.0729 (.5294704d) Dec: -02 56 5.68 (-2.93491d) Equinox: J2000		V=26	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[GAMMA RAY BURSTER]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F438W	FLASH=7	POS TARG -54.843 04796804822,20.994 436025262832; GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-2 in Visit T2 (1)	550 Secs (2200 Secs)	
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2		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F606W		POS TARG -54.843 04796804822,20.994 436025262832	Pattern 1, Exps 1-2 in Visit T2 (1)	550 Secs (2200 Secs)	
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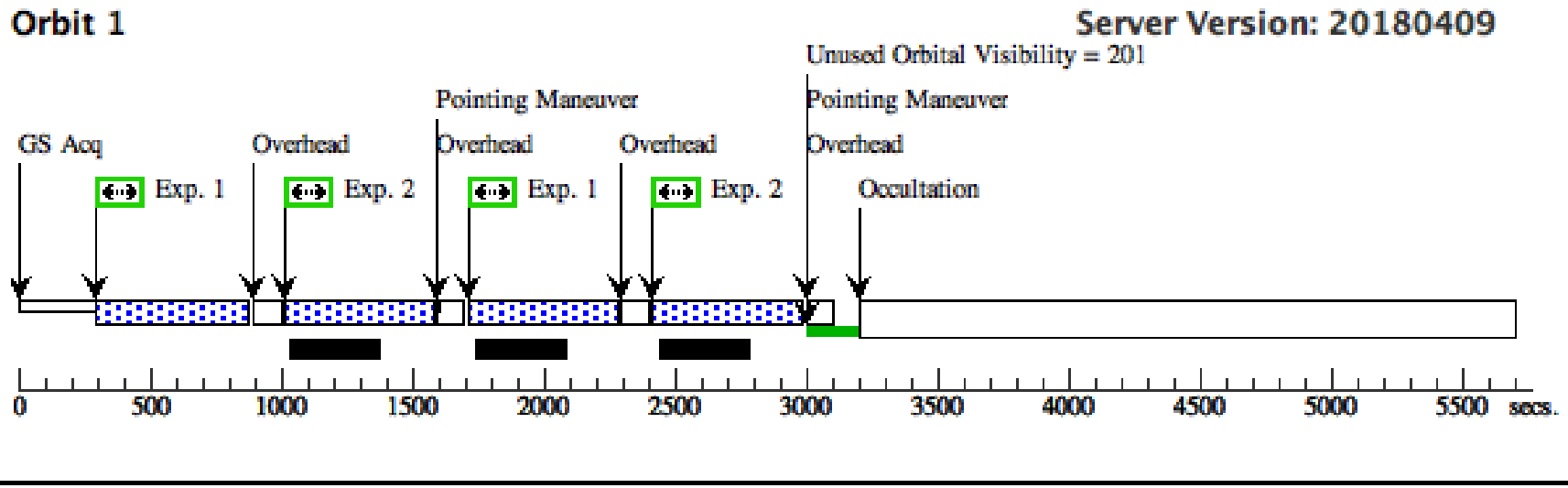
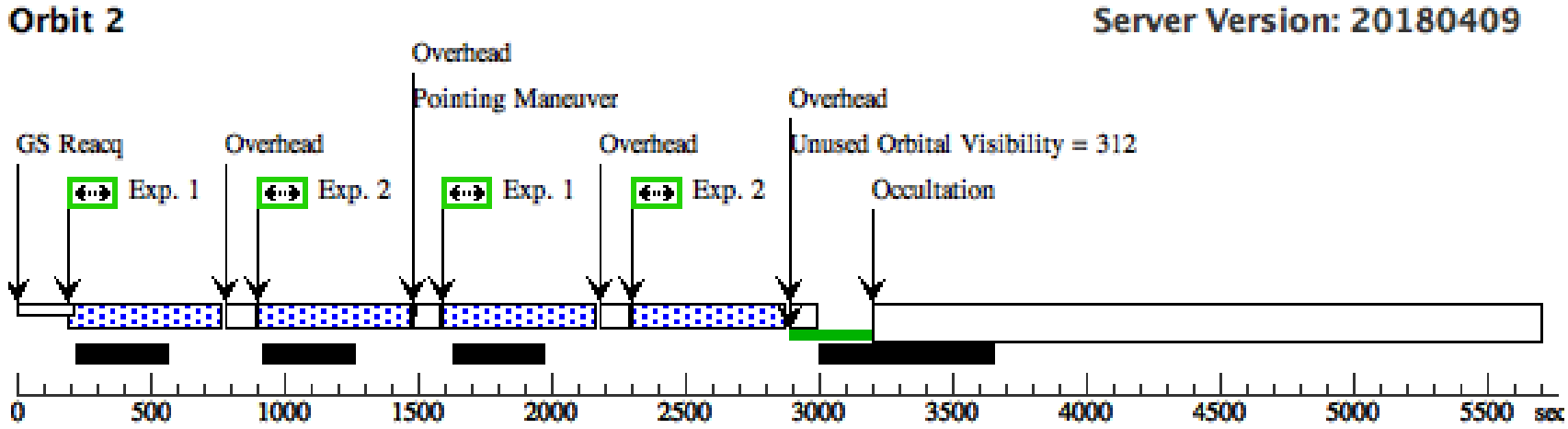
Orbit Structure





Visit

Proposal 15613, Visit T3, implementation Mon Sep 17 22:00:23 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

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Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GRB-180720B	RA: 00 02 7.0729 (.5294704d) Dec: -02 56 5.68 (-2.93491d) Equinox: J2000		V=26	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[GAMMA RAY BURSTER]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F438W	FLASH=7	POS TARG 54.8430 4796804822,20.9944 36025262832; GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-2 in Visit T3 (1)	550 Secs (2200 Secs)	
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2		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS1	F606W		POS TARG 54.8430 4796804822,20.9944 36025262832	Pattern 1, Exps 1-2 in Visit T3 (1)	550 Secs (2200 Secs)	
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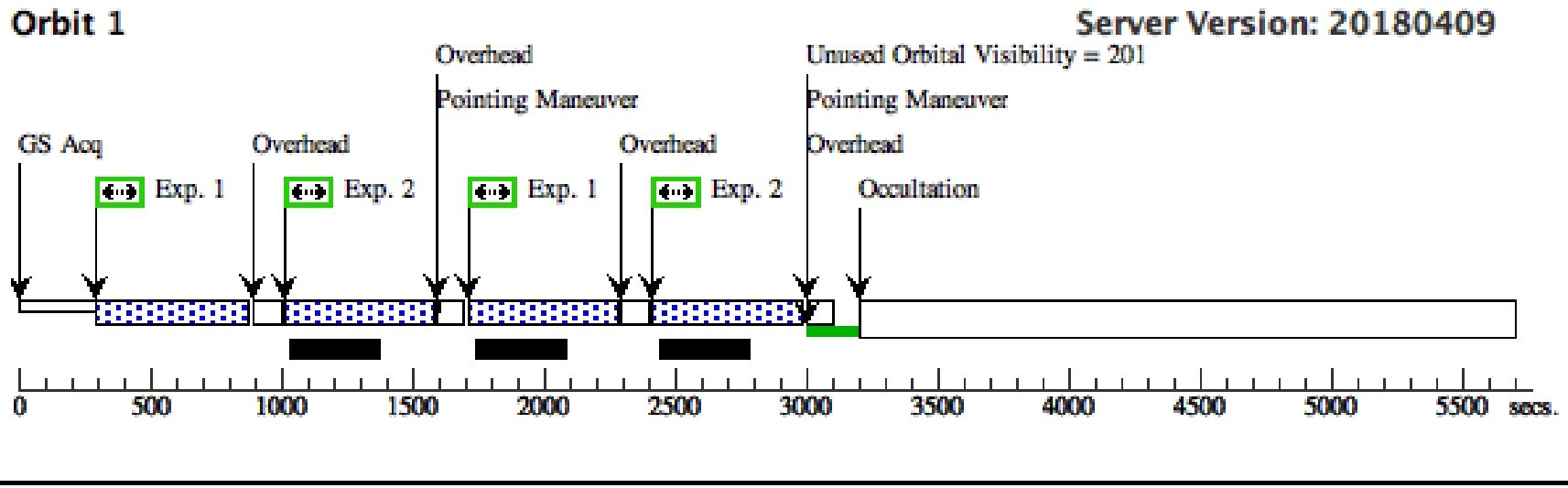
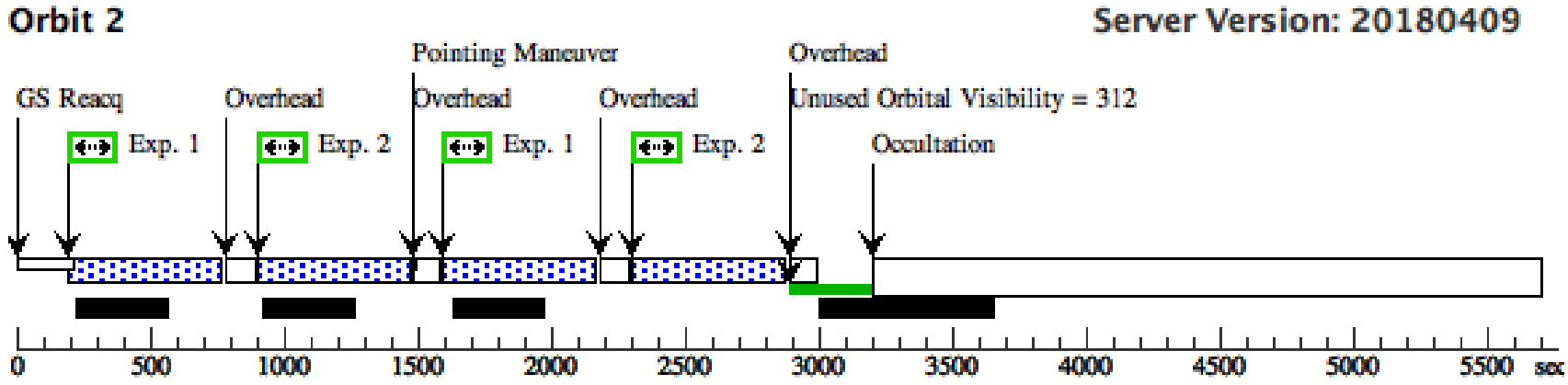
Orbit Structure





Visit

Proposal 15613, Visit T5, implementation Mon Sep 17 22:00:23 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

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Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GRB-180720B	RA: 00 02 7.0729 (.5294704d) Dec: -02 56 5.68 (-2.93491d) Equinox: J2000		V=26	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[GAMMA RAY BURSTER]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS2	F438W	FLASH=7	GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-2 in Visit T5 (1)	550 Secs (2200 Secs)	
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2		(1) GRB-180720B	WFC3/UVIS, ACCUM, UVIS2	F606W			Pattern 1, Exps 1-2 in Visit T5 (1)	550 Secs (2200 Secs)	
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								[==>(Pattern 3)] *[==>(Pattern 4)]*	***[2]***

Orbit Structure