17277 - Spatially Resolving the First z>1 Fast Radio Burst Host Galaxy

Cycle: 30, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Mrs. Alexa Gordon (PI) (Contact)	**Northwestern University**	**alexagordon2026@u.northwestern.edu**
Dr. Wen-fai Fong (CoI)	Northwestern University	wfong@northwestern.edu
Dr. Charles Kilpatrick (CoI)	Northwestern University	ckilpatrick@northwestern.edu
Dr. Jason X. Prochaska (CoI)	University of California - Santa Cruz	xavier@ucolick.org
Mr. Sunil Simha (CoI)	University of California - Santa Cruz	shassans@ucsc.edu
Dr. Nicolas Tejos (CoI)	Pontificia Universidad Catolica de Valparaiso	ntejos@gmail.com
Dr. Marc Rafelski (CoI) (Contact)	Space Telescope Science Institute	mrafelski@stsci.edu
Dr. Kameswara Bharadwaj Mantha (CoI)	University of Minnesota - Twin Cities	km4n6@mail.umkc.edu
Dr. Ryan Shannon (CoI)	Swinburne University of Technology	ryanmshannon@gmail.com
Dr. Adam Travis Deller (CoI)	Swinburne University of Technology	adeller@astro.swin.edu.au
Dr. Stuart Ryder (CoI)	Macquarie University	stuart.ryder@mq.edu.au
Lachlan Marnoch (CoI)	Macquarie University	lachlan.marnoch@hdr.mq.edu.au

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) FRB20220610A	WFC3/UVIS	2	09-Dec-2022 12:00:28.0	yes
02	(1) FRB20220610A	WFC3/IR	2	09-Dec-2022 12:00:29.0	yes

4 Total Orbits Used

ABSTRACT

Fast radio bursts (FRBs) are bright millisecond pulses that are prolific in the universe but have uncertain progenitors. The recent localization of FRB 20220610A to a z~1 host galaxy marked a new era in FRB science. As the furthest securely-localized FRB to date by a factor of two and most energetic by a factor of four, this burst is already revolutionizing our understanding of these events. In particular, this FRB directly probed ionized gas and magnetic fields in the intergalactic medium to times approaching the peak of cosmic star formation. Given the uncertainty of FRB progenitors, host galaxy environments offer vital clues. However, current ground-based imaging of FRB 20220610A reveals a complex host galaxy structure, suggestive of multiple galaxies and possibly indicative of an ongoing galaxy merger. As these data cannot resolve the components individually, we propose 4 orbits of HST imaging to discern the true morphology of this system, potentially uncover signs of a galaxy-scale merger, and delineate how this FRB traces its host galaxy's star formation and stellar mass distributions. These observations will give clear context for the proper interpretation of the ground-based observations and provide a key puzzle piece to the first FRB at z~1.

OBSERVING DESCRIPTION

This program images a newly discovered FRB host galaxy at z~1 to measure the morphological structure of a complex host galaxy, suggestive of multiple galaxies and possibly indicative of an ongoing galaxy merger. As current ground-based data cannot resolve the components individually, we will use HST imaging to discern the true morphology of this system, potentially uncover signs of a galaxy-scale merger, and delineate how this FRB traces its host galaxy's star formation and stellar mass distributions.

The rest-frame NUV (observed optical) will be sampled by the WFC3/UVIS F606W filter tracing recent star formation via young stars and yielding the highest possible resolution to distinguish the nature of the three components. The rest-frame optical (observed NIR) will be sampled by the WFC3/IR F160W filter. This is the reddest wide filter available on HST to measure the distribution of the stellar mass as traced by the old stellar populations.

In order to obtain images clean of cosmic rays and image artifacts and sampling the PSF phase, we use custom dither patterns with 6 and 8 positions. For the optical measurements we will obtain six exposures, which also ensures no saturation for our somewhat bright target. Given the high background in the wide F606W bandpass, no post-flash is necessary. To minimize our pixel-based CTE correction, we place the target on chip 2 close to the readout. For the NIR observations, we wish to stay in the linear regime and minimize persistence with our bright target, and therefore will use SPAR50 with NSAMP of 13. Since this sets the exposure time per dither position, we end up with 4 dither positions per orbit for a total of 8 dither positions.

As requested in the Phase I, to avoid a larger 4 orbit visit, we break up the filters into two orbits each and tie the orientations of the two filters to each other (within 5 degrees) to ensure sufficient targets in common to align the images to each other preceisely. We use a pos-targ offset of -55" and -45" in x and y, respectively, to align the IR detector on the WFC3/UVIS CTE aperture.

For the WFC3/UVIS exposures, we use a dither pattern that is 5 times the custom 6 point dither pattern from WFC3/UVIS ISR 2020-07 (pg 14) to remove residual background patterns. For the WFC3/IR exposures, we use the 8-point wide dither pattern from WFC3/IR ISR 2016-14 (pg 17) to get a good dither for the pixel phase and artifiact mitigation. We multiply those values by 3 to better deal with IR blobs and self persistence. The large number of dithers for the IR is due to the desire to use SPAR50 as described above.

We note that there is a 10th magnitude star in the upper north-west of our potential field of view. If scheduled at a PA of around 125 degrees, the star would fall on Chip 1, but the optical ghosts would fall in a favorable direction away from our target. However, if we are at a PA of around 110 degrees, there may be dragons breath on the detector. We believe that it would not impact the science target based on the orientation and the location of our science target, but if this is not the case, please reach out to the observers.

We do not forsee any issues if we have to go to 1 gyro mode as we can observe at any absolute orientation, we just need the orientation of our two filters to be matched. If they can't be matched, we can also adjust the post-targ to allow different orientations between the visits as needed.

Visit

Proposal 17277, Visit 01 — Fri Dec 09 17:00:30 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Fixed Targets

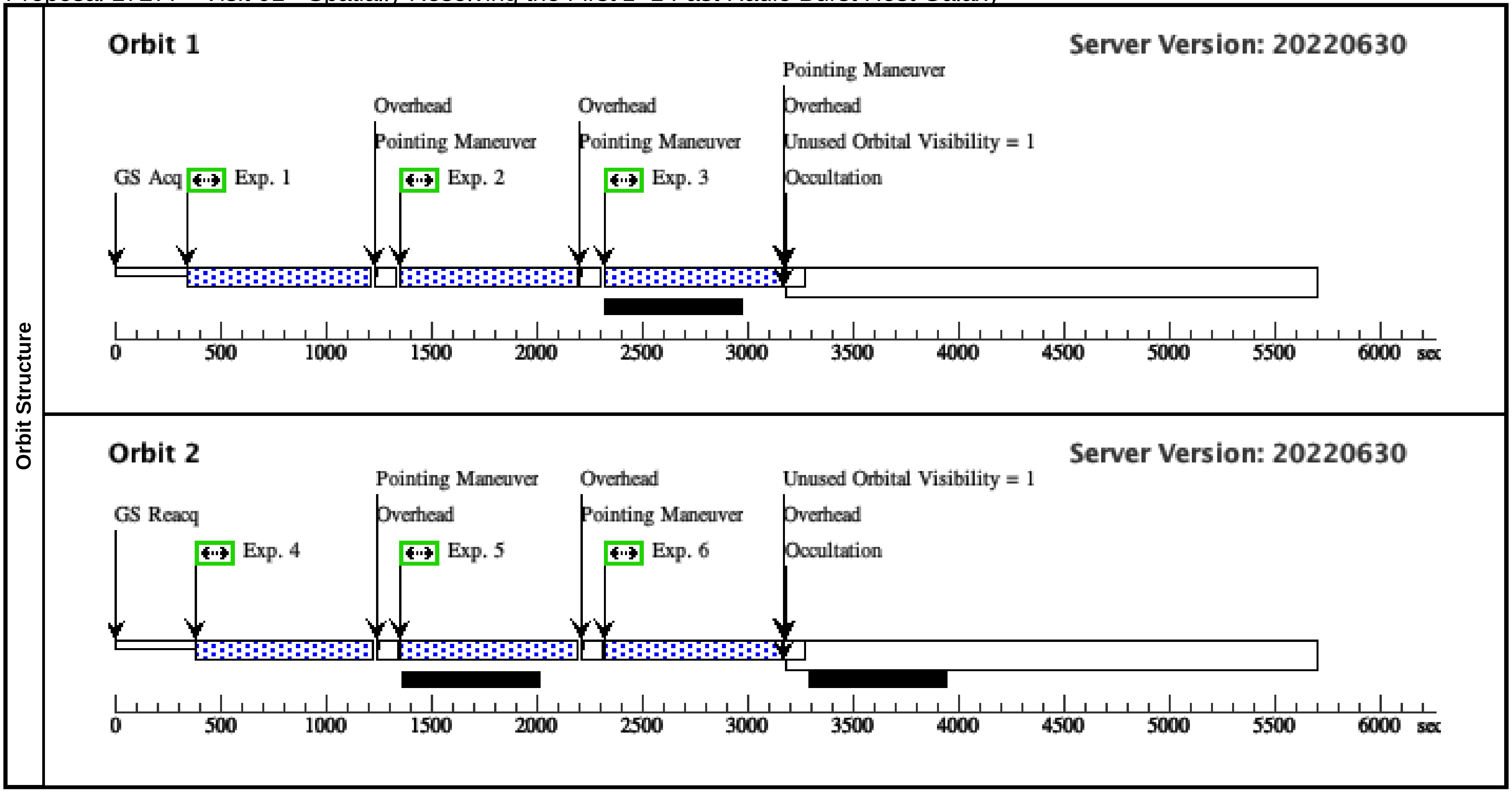
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	FRB20220610A	RA: 23 24 17.6359 (351.0734829d) Dec: -33 30 49.18 (-33.51366d) Equinox: J2000		V=23.9+/-0.1	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[AMORPHOUS IRREGULAR, INTERACTING GALAXY, MULTIPLE NUCLEI]
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) FRB20220610A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F606W				830 Secs (844 Secs) *[==>844.0 Secs]*	***[1]***
2		(1) FRB20220610A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F606W		POS TARG 0.4635,1.6880		830 Secs (844 Secs) *[==>844.0 Secs]*	***[1]***
3		(1) FRB20220610A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F606W		POS TARG 0.9255,0.9890		830 Secs (844 Secs) *[==>844.0 Secs]*	***[1]***
4		(1) FRB20220610A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F606W		POS TARG 1.1910,2.5650		830 Secs (841 Secs) *[==>841.0 Secs]*	***[2]***
5		(1) FRB20220610A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F606W		POS TARG 1.6525,1.8660		830 Secs (841 Secs) *[==>841.0 Secs]*	***[2]***
6		(1) FRB20220610A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F606W		POS TARG 2.5120,2.5855		830 Secs (841 Secs) *[==>841.0 Secs]*	***[2]***

Proposal 17277 - Visit 01 - Spatially Resolving the First z>1 Fast Radio Burst Host Galaxy



Visit

Proposal 17277, Visit 02

Fri Dec 09 17:00:30 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT -5D TO 5D FROM 01

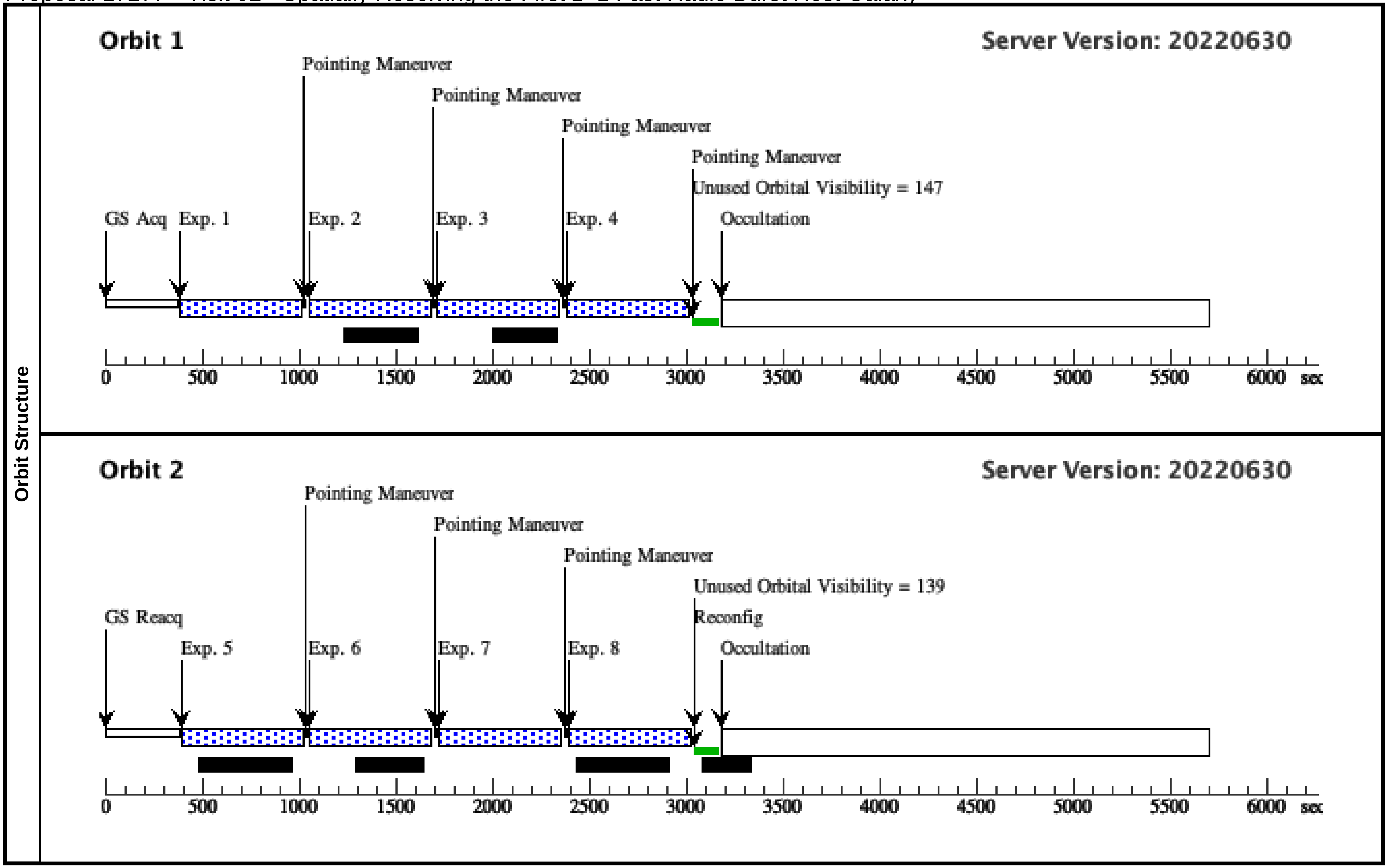
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	FRB20220610A	RA: 23 24 17.6359 (351.0734829d) Dec: -33 30 49.18 (-33.51366d) Equinox: J2000		V=23.9+/-0.1	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[AMORPHOUS IRREGULAR, INTERACTING GALAXY, MULTIPLE NUCLEI]
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -55,-45		602.937703 Secs (602.938 Secs) *[==>]*	*[1]*
2		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -52.9180,-44.8600		602.937703 Secs (602.938 Secs) *[==>]*	*[1]*
3		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -50.8360,-44.7150		602.937703 Secs (602.938 Secs) *[==>]*	*[1]*
4		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -54.8470,-43.1400		602.937703 Secs (602.938 Secs) *[==>]*	*[1]*
5		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -52.7650,-42.9960		602.937703 Secs (602.938 Secs) *[==>]*	*[2]*
6		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -50.6800,-42.8520		602.937703 Secs (602.938 Secs) *[==>]*	*[2]*
7		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -53.8810,-41.2740		602.937703 Secs (602.938 Secs) *[==>]*	*[2]*
8		(1) FRB20220610A	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=13; SAMP-SEQ=SPARS50	POS TARG -51.7990, -41.1330		602.937703 Secs (602.938 Secs) *[==>]*	*[2]*


Orbit Structure
Orbit 1
Server Version: 20220630
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Orbital Visibility = 147
GS Acq
Exp. 1
Exp. 2
Exp. 3
Exp. 4
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec
Orbit 2
Server Version: 20220630
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Orbital Visibility = 139
GS Reacq
Reconfig
Exp. 5
Exp. 6
Exp. 7
Exp. 8
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec