# 15460 - The Orbit of the Newly Discovered Satellite around the Dwarf Planet 2013 FY27

Cycle: 25, Proposal Category: GO

(Availability Mode: SUPPORTED)

**INVESTIGATORS**



| *Name* | *Institution* | *E-Mail* |
|---|---|---|
| **Dr. Scott Sander Sheppard (PI) (Contact)** | **Carnegie Institution of Washington** | **sheppard@dtm.ciw.edu** |
| Prof. Darin Ragozzine (CoI) | Brigham Young University | darin_ragozzine@byu.edu |



**VISITS**

| *Visit* | *Targets used in Visit* | *Configurations used in Visit* | *Orbits Used* | *Last Orbit Planner Run* | *OP Current with Visit?* |
|---|---|---|---|---|---|
| 01 | (1) 2013FY27 | WFC3/IR<br>WFC3/UVIS | 1 | 19-Jun-2018 13:17:06.0 | yes |
| 02 | (1) 2013FY27 | WFC3/UVIS | 1 | 19-Jun-2018 13:17:07.0 | yes |
| 03 | (1) 2013FY27 | WFC3/UVIS | 1 | 19-Jun-2018 13:17:09.0 | yes |
| 04 | (1) 2013FY27 | WFC3/IR<br>WFC3/UVIS | 1 | 19-Jun-2018 13:17:10.0 | yes |
| 51 | (1) 2013FY27 | WFC3/IR<br>WFC3/UVIS | 1 | 19-Jun-2018 13:17:12.0 | yes |

5 Total Orbits Used

**ABSTRACT**

From our HST observations in January we discovered that dwarf planet 2013 FY27 has a satellite that is 2.8 mags fainter and 0.16 arcsecs from the primary. 2013 FY27 is the ninth intrinsically brightest trans-Neptunian object (TNO), and thus likely one of the largest. 2013 FY27 is extra interesting because its size is likely in the transition region of TNO structure. The largest few TNOs all have satellites, which show the largest TNOs have higher densities than the smaller TNOs. There are not many known intermediate sized TNOs like 2013 FY27 with satellites, of which 2013 FY27 is likely the largest and just at the beginning of the transition region from high to low density. This borderline intermediate to large sized TNO will allow us to probe the transition of high density to low density TNOs. 2013 FY27 is by far the largest TNO with a known satellite to not have the satellite's orbit known or soon to be known.

We also just observed 2013 FY27 with ALMA, which will give us a size and albedo and thus allow us to obtain the mass and bulk density of 2013 FY27 if we know the satellite's orbit. Calculating the satellite's orbit requires 5 well separated observations. We currently have just the one discovery detection, and thus no motion of the satellite. We request 4 additional orbits with HST now so we can use our recent prior detection with the first few new detections to predict the optimal next time to observe it in April and May, which could save HST time. Also, the next HST GO proposal cycle does not allow small programs, which means our discovery detection will not be useful in predicting optimal HST observing times in the far future.

**OBSERVING DESCRIPTION**

We found a satellite around asteroid 2013 FY27 with HST images in Janauary 2018.

We now want to observe this satellite at 4 different epochs in order to get the orbit of the satellite.

This object is only up for the next month or so before being lost behind the Sun.

We want to observe it ASAP with two different HST orbits scheduled about 2 days apart. We will then use those observations to predict when would be optimal to observe the satellite a third and fourth time, a few weeks later.

If dynamic scheduling is not possible, we can schedule all 4 HST orbits now with seperations of about 2 days, 5 days and 12 days. This will not give us optimal coverage, but will likely be okay, but the satellite could be too close and thus confused with the primary if we don't have optimal dynamic scheduling.

## Visit

**Proposal 15460, 1 (01), failed** Tue Jun 19 17:17:13 GMT 2018

**Diagnostic Status: Warning**

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: PCS MODE FINE

*Comments: First visit of dwarf planet 2013 FY27. To do As Soon As Possible.*

## Diagnostics

(1 (01.005)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

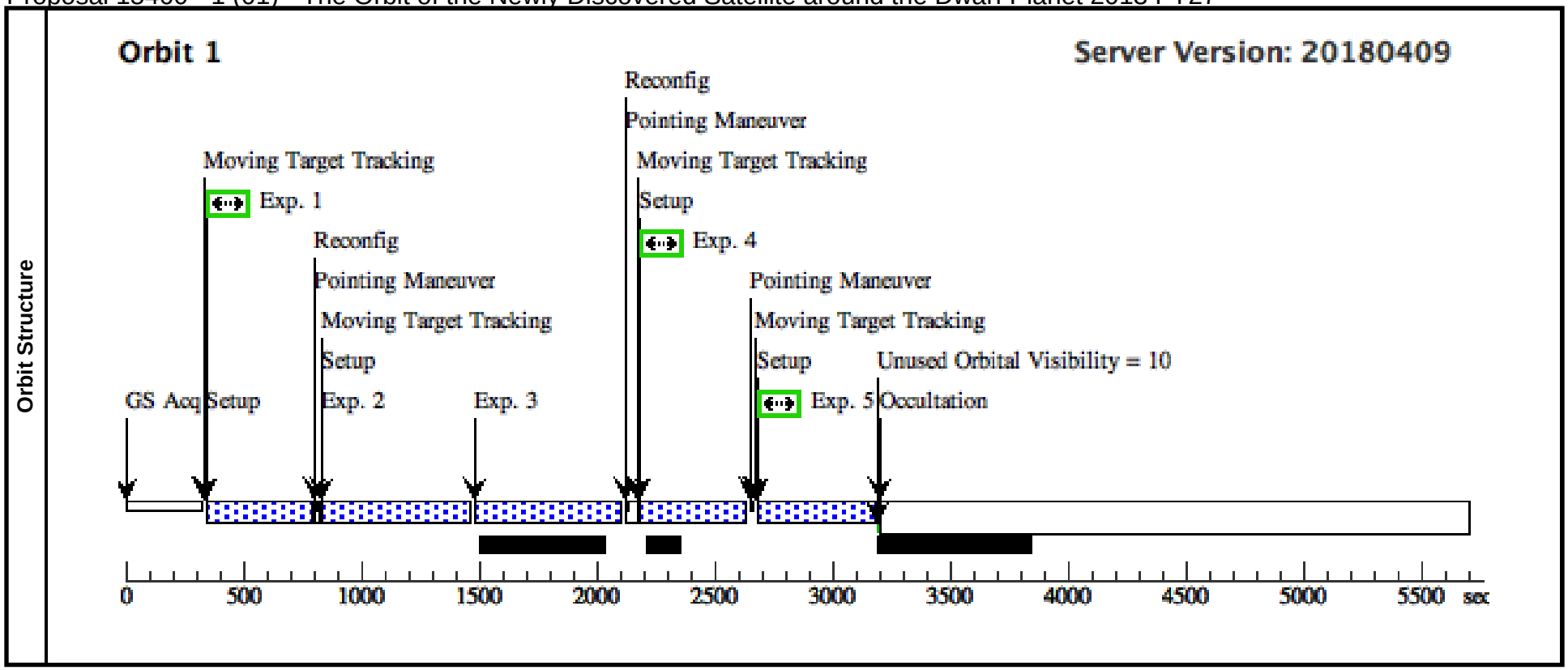
## Solar System Targets

| # | Name | Level 1 | Level 2 | Level 3 | Window | Ephem Center |
|---|---|---|---|---|---|---|
| (1) | 2013FY27 | TYPE=ASTEROID,A=58.8711252946 7599,E=0.3906163476853069,I=33.11 838655782182,O=187.0531645959515 ,W=139.6951422033165,M=207.7450 731986418,EQUINOX=J2000,EPOCH =25-AUG- 2013:00:00:00,EpochTimeScale=TDB | | | | EARTH |

*Comments: Need to observe 2013 FY27 with several images to monitor its newly found satellite. Need a few days between HST orbit visits in order to see the satellite move and thus calculate its orbit.*
*Description=Asteroid 2013 FY27*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F350LP | | POS TARG 0.0,0.0 | | 300 Secs (300 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 2 | 1 | (1) 2013FY27 | WFC3/IR, MULTIACCUM, IR | F139M | NSAMP=7; SAMP-SEQ=SPAR S100 | | | 602.934229 Secs (602.934 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 3 | 1 | (1) 2013FY27 | WFC3/IR, MULTIACCUM, IR | F153M | NSAMP=7; SAMP-SEQ=SPAR S100 | | | 602.934229 Secs (602.934 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 4 | 1 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F606W | | POS TARG 0.158,0. 070 | | 310 Secs (310 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 5 | 1 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F814W | | POS TARG 0.099,0. 165 | | 360 Secs (360 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |


Orbit Structure
Orbit 1
Server Version: 20180409
Moving Target Tracking
Exp. 1
Reconfig
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 2
Reconfig
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 4
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 5
Unused Orbital Visibility = 10
GS Acq Setup
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

## Visit

**Proposal 15460, 2 (02), completed** Tue Jun 19 17:17:13 GMT 2018

**Diagnostic Status: No Diagnostics**

Scientific Instruments: WFC3/UVIS

Special Requirements: PCS MODE FINE; AFTER 01 BY 1.5 D TO 2.5 D

*Comments: Second visit of dwarf planet 2013 FY27. To do 1.5 to 2.5 days after first visit.*

## 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 | | (2), (3) |

## Solar System Targets

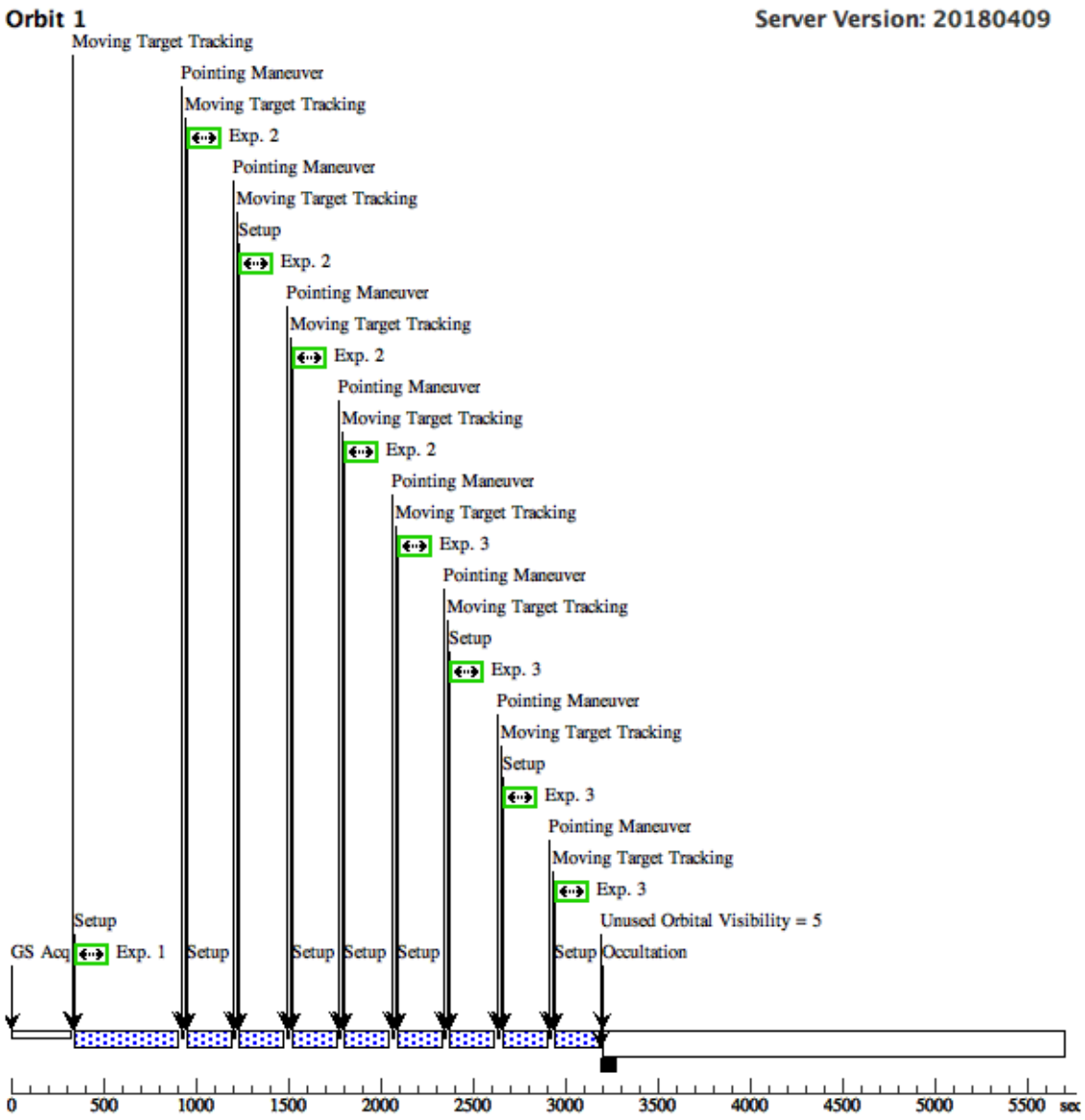
| # | Name | Level 1 | Level 2 | Level 3 | Window | Ephem Center |
|---|---|---|---|---|---|---|
| (1) | 2013FY27 | TYPE=ASTEROID,A=58.87112529467599,E=0.3906163476853069,I=33.11838655782182,O=187.0531645959515,W=139.6951422033165,M=207.7450731986418,EQUINOX=J2000,EPOCH=25-AUG-2013:00:00:00,EpochTimeScale=TDB | | | | EARTH |

*Comments: Need to observe 2013 FY27 with several images to monitor its newly found satellite. Need a few days between HST orbit visits in order to see the satellite move and thus calculate its orbit.*
*Description=Asteroid 2013 FY27*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB | F350LP | | POS TARG 0.0,0.0 | | 500 Secs (457 Secs)<br>*[==>457.0 Secs ]* | <br>***[1]*** |
| 2 | 2 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C512C-SUB | F350LP | | POS TARG 0.158,0.070 | Pattern 1, Exps 2-2 in 2 (02) (1) | 200 Secs (800 Secs)<br>*[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | <br>***[1]*** |
| 3 | 2 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C512C-SUB | F350LP | | POS TARG 0.158,0.070 | Pattern 1, Exps 3-3 in 2 (02) (1) | 200 Secs (800 Secs)<br>*[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | <br>***[1]*** |

Orbit Structure



## Visit

**Proposal 15460, 3 (03), implementation** Tue Jun 19 17:17:13 GMT 2018

**Diagnostic Status: Warning**

Scientific Instruments: WFC3/UVIS

Special Requirements: PCS MODE FINE

*Comments: Third visit of dwarf planet 2013 FY27. To do ASAP.*

## Diagnostics

(3 (03)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

## 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 | | (2), (3) |

## Solar System Targets

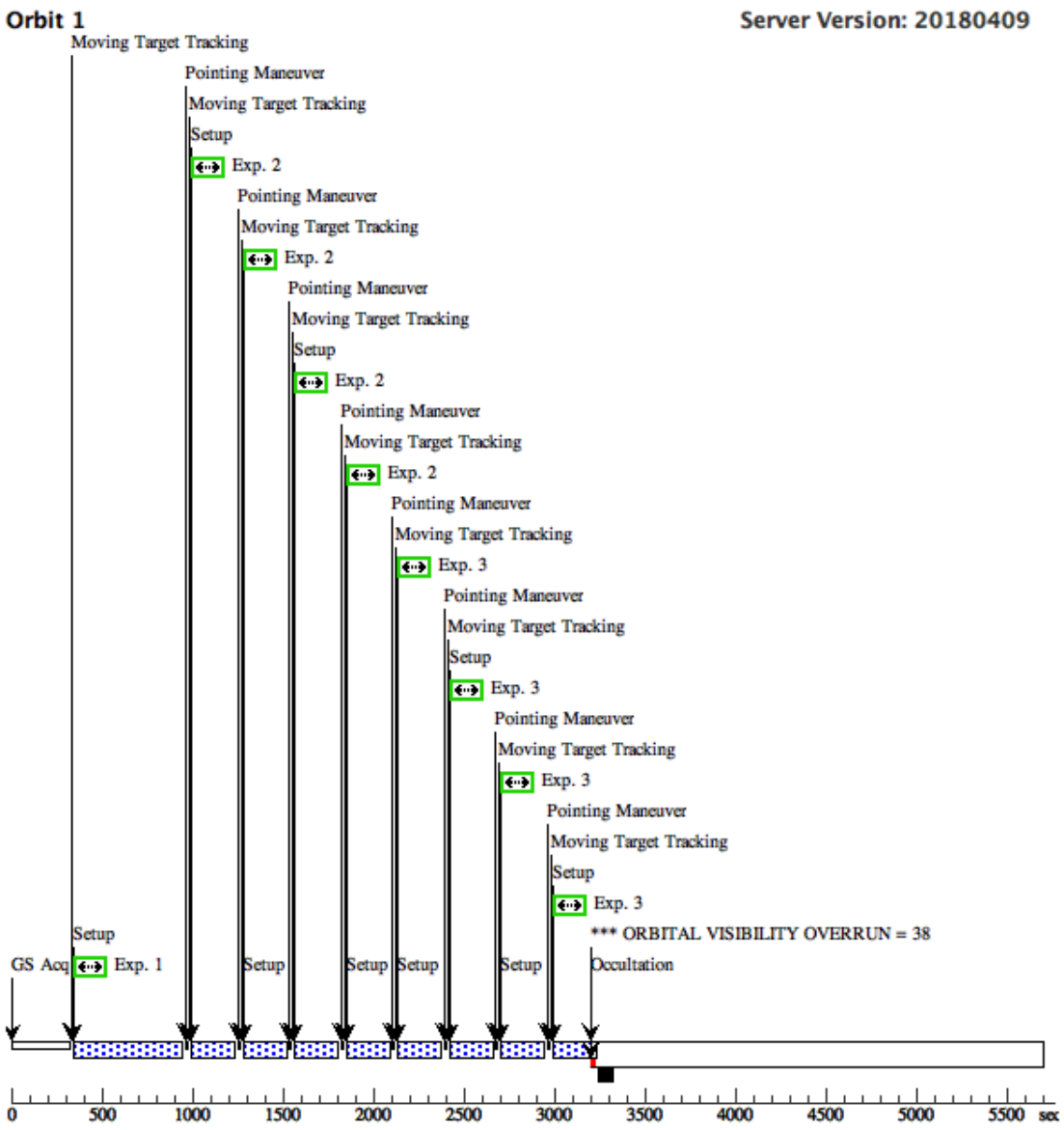
| # | Name | Level 1 | Level 2 | Level 3 | Window | Ephem Center |
|---|---|---|---|---|---|---|
| (1) | 2013FY27 | TYPE=ASTEROID,A=58.87112529467599,E=0.3906163476853069,I=33.11838655782182,O=187.0531645959515,W=139.6951422033165,M=207.7450731986418,EQUINOX=J2000,EPOCH=25-AUG-2013:00:00:00,EpochTimeScale=TDB | | | | EARTH |

*Comments: Need to observe 2013 FY27 with several images to monitor its newly found satellite. Need a few days between HST orbit visits in order to see the satellite move and thus calculate its orbit.*
*Description=Asteroid 2013 FY27*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB | F350LP | | POS TARG 0.0,0.0 | Sequence 1-3 Non-Int in 3 (03) | 500 Secs (500 Secs)<br>*[==>]* | <br>***[1]*** |
| 2 | 3 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C512C-SUB | F350LP | | POS TARG 0.158,0.070 | Sequence 1-3 Non-Int in 3 (03)<br>Pattern 1, Exps 2-2 in Sequence 1-3 Non-Int in 3 (03) (1) | 200 Secs (800 Secs)<br>*[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | <br>***[1]*** |
| 3 | 3 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C512C-SUB | F350LP | | POS TARG 0.158,0.070 | Sequence 1-3 Non-Int in 3 (03)<br>Pattern 1, Exps 3-3 in Sequence 1-3 Non-Int in 3 (03) (1) | 200 Secs (800 Secs)<br>*[==>(Pattern 1)]*<br>*[==>(Pattern 2)]*<br>*[==>(Pattern 3)]*<br>*[==>(Pattern 4)]* | <br>***[1]*** |

Orbit Structure



## Visit

**Proposal 15460, 4 (04), implementation** Tue Jun 19 17:17:13 GMT 2018

**Diagnostic Status: Warning**

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: PCS MODE FINE; AFTER 03 BY 2.0 D TO 2.5 D

*Comments: Fourth visit of dwarf planet 2013 FY27. To do a few days after Visit 3.*

## Diagnostics

(4 (04.005)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

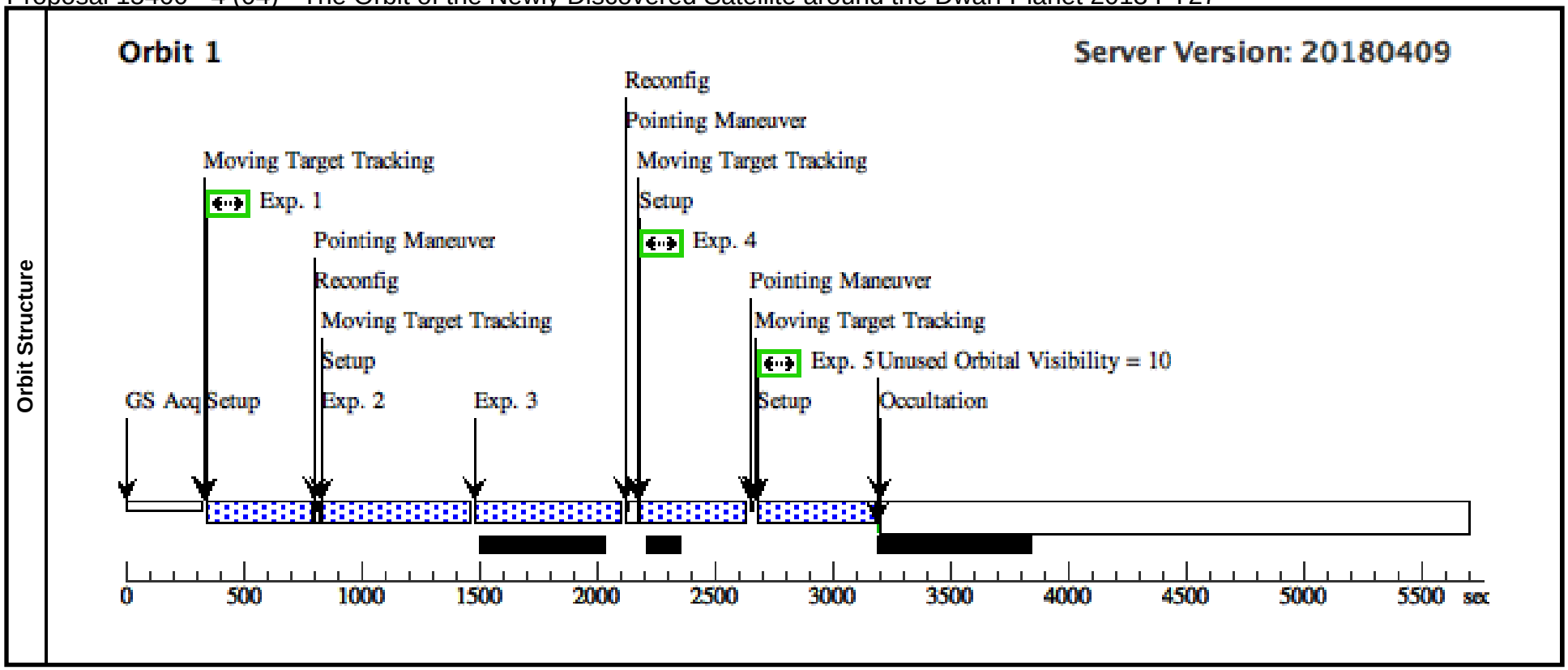
## Solar System Targets

| # | Name | Level 1 | Level 2 | Level 3 | Window | Ephem Center |
|---|---|---|---|---|---|---|
| (1) | 2013FY27 | TYPE=ASTEROID,A=58.8711252946 7599,E=0.3906163476853069,I=33.11 838655782182,O=187.0531645959515 ,W=139.6951422033165,M=207.7450 731986418,EQUINOX=J2000,EPOCH =25-AUG- 2013:00:00:00,EpochTimeScale=TDB | | | | EARTH |

*Comments: Need to observe 2013 FY27 with several images to monitor its newly found satellite. Need a few days between HST orbit visits in order to see the satellite move and thus calculate its orbit.*
*Description=Asteroid 2013 FY27*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F350LP | | POS TARG 0.0,0.0 | Sequence 1-5 Non-Int in 4 (04) | 300 Secs (300 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 2 | 4 | (1) 2013FY27 | WFC3/IR, MULTIACCUM, IR | F139M | NSAMP=7; SAMP-SEQ=SPARS100 | | Sequence 1-5 Non-Int in 4 (04) | 602.934229 Secs (602.934 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 3 | 4 | (1) 2013FY27 | WFC3/IR, MULTIACCUM, IR | F153M | NSAMP=7; SAMP-SEQ=SPARS100 | | Sequence 1-5 Non-Int in 4 (04) | 602.934229 Secs (602.934 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 4 | 4 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F606W | | POS TARG 0.158,0.070 | Sequence 1-5 Non-Int in 4 (04) | 310 Secs (310 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 5 | 4 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F814W | | POS TARG 0.099,0.165 | Sequence 1-5 Non-Int in 4 (04) | 360 Secs (360 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |


Orbit Structure
Orbit 1
Server Version: 20180409
Moving Target Tracking
Exp. 1
Pointing Maneuver
Reconfig
Moving Target Tracking
Setup
Exp. 2
Reconfig
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 4
Pointing Maneuver
Moving Target Tracking
Exp. 5
Unused Orbital Visibility = 10
GS Acq
Setup
Exp. 3
Setup
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

## Visit

**Proposal 15460, 5 (51), implementation** Tue Jun 19 17:17:13 GMT 2018

**Diagnostic Status: Warning**

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: PCS MODE FINE; AFTER 04 BY 3.0 D TO 3.5 D

*Comments: Fifth visit, to do a few days after Visit 4.*

## Diagnostics

(5 (51.005)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

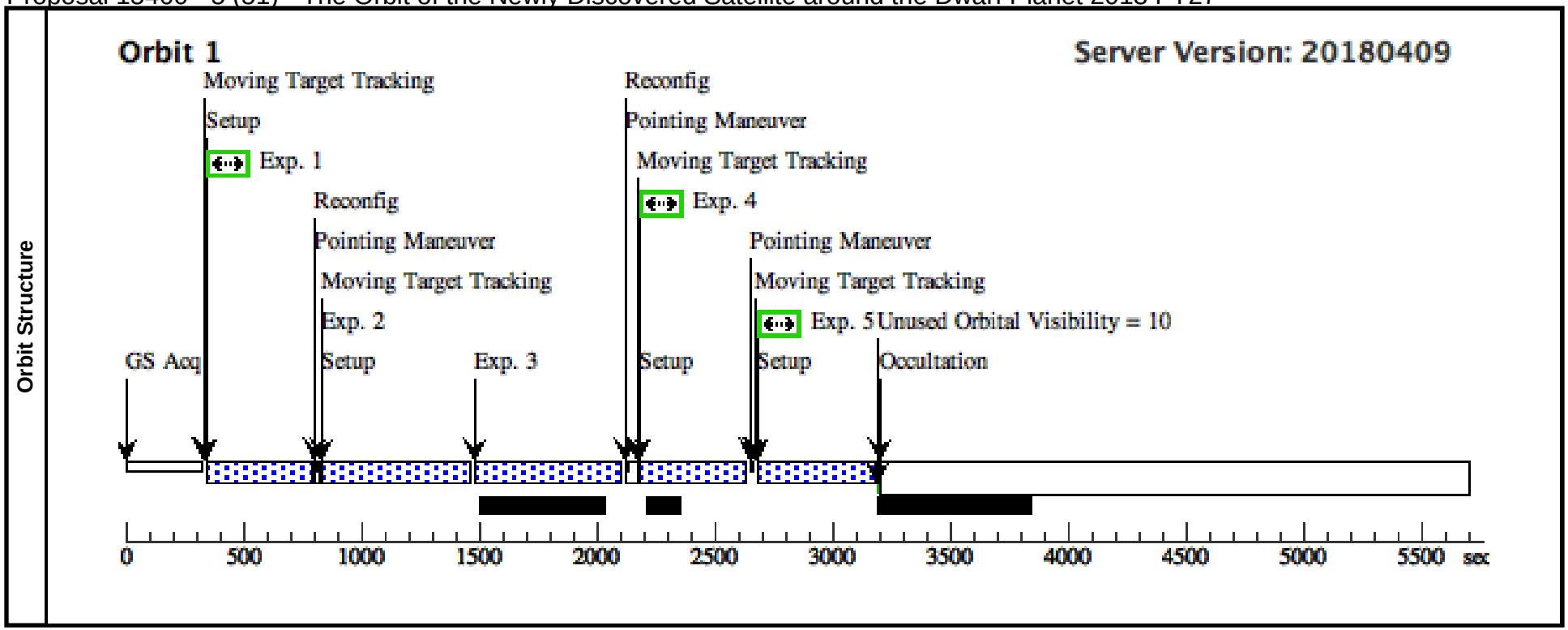
## Solar System Targets

| # | Name | Level 1 | Level 2 | Level 3 | Window | Ephem Center |
|---|---|---|---|---|---|---|
| (1) | 2013FY27 | TYPE=ASTEROID,A=58.8711252946 7599,E=0.3906163476853069,I=33.11 838655782182,O=187.0531645959515 ,W=139.6951422033165,M=207.7450 731986418,EQUINOX=J2000,EPOCH =25-AUG- 2013:00:00:00,EpochTimeScale=TDB | | | | EARTH |

*Comments: Need to observe 2013 FY27 with several images to monitor its newly found satellite. Need a few days between HST orbit visits in order to see the satellite move and thus calculate its orbit.*
*Description=Asteroid 2013 FY27*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F350LP | | POS TARG 0.0,0.0 | Sequence 1-5 Non-In t in 5 (51) | 300 Secs (300 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 2 | 5 | (1) 2013FY27 | WFC3/IR, MULTIACCUM, IR | F139M | NSAMP=7; SAMP-SEQ=SPAR S100 | | Sequence 1-5 Non-In t in 5 (51) | 602.934229 Secs (602.934 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 3 | 5 | (1) 2013FY27 | WFC3/IR, MULTIACCUM, IR | F153M | NSAMP=7; SAMP-SEQ=SPAR S100 | | Sequence 1-5 Non-In t in 5 (51) | 602.934229 Secs (602.934 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 4 | 5 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F606W | | POS TARG 0.158,0. 070 | Sequence 1-5 Non-In t in 5 (51) | 310 Secs (310 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |
| 5 | 5 | (1) 2013FY27 | WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE | F814W | | POS TARG 0.099,0. 165 | Sequence 1-5 Non-In t in 5 (51) | 360 Secs (360 Secs) | |
| | | | | | | | | *[==>]* | ***[1]*** |


Orbit Structure
Orbit 1
Server Version: 20180409
Moving Target Tracking
Setup
Exp. 1
Reconfig
Pointing Maneuver
Moving Target Tracking
Exp. 2
GS Acq
Setup
Exp. 3
Reconfig
Pointing Maneuver
Moving Target Tracking
Exp. 4
Setup
Pointing Maneuver
Moving Target Tracking
Exp. 5
Setup
Unused Orbital Visibility = 10
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec