



# 15953 - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary Nebulae NGC 7027 and NGC 6302

Cycle: 27, Proposal Category: GO

(Availability Mode: SUPPORTED)

## INVESTIGATORS

| <i>Name</i>                               | <i>Institution</i>                                | <i>E-Mail</i>               |
|-------------------------------------------|---------------------------------------------------|-----------------------------|
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## VISITS

| <i>Visit</i> | <i>Targets used in Visit</i> | <i>Configurations used in Visit</i> | <i>Orbits Used</i> | <i>Last Orbit Planner Run</i> | <i>OP Current with Visit?</i> |
|--------------|------------------------------|-------------------------------------|--------------------|-------------------------------|-------------------------------|
| 01           | (2) NGC-6302                 | WFC3/UVIS                           | 4                  | 14-Feb-2020 16:00:17.0        | yes                           |
| 05           | (2) NGC-6302                 | WFC3/UVIS                           | 2                  | 14-Feb-2020 16:00:18.0        | yes                           |
| 03           | (1) NGC-7027                 | WFC3/UVIS                           | 3                  | 14-Feb-2020 16:00:20.0        | yes                           |
| 02           | (2) NGC-6302                 | WFC3/IR                             | 2                  | 14-Feb-2020 16:00:22.0        | yes                           |
| 04           | (1) NGC-7027                 | WFC3/IR                             | 2                  | 14-Feb-2020 16:00:24.0        | yes                           |

13 Total Orbits Used

## ABSTRACT

Planetary nebulae (PNe) serve as textbook examples of astrophysical plasmas and shock processes and provide essential tests of theories of stellar evolution and the origin and enrichment of the heavy elements in the universe. HST imaging has established that PNe exhibit a dazzling variety of aspherical morphologies: elliptical; bipolar or multipolar; highly point-symmetric; chaotic and clumpy. The multifaceted PN shaping problem has connections to (and implications for) a wide variety of astrophysical systems: binary star astrophysics; stellar wind interactions and shocks; the physics and chemistry of photoionized plasmas and photon-dominated regions; and enrichment of the ISM in the products of intermediate-mass stellar nucleosynthesis. Yet, as the useful lifetime of HST comes to a close, the tremendous potential of HST/WFC3 to obtain a comprehensive set of near-UV/optical/near-IR emission-line images has yet to be exploited for any PN. Here, we propose the first such comprehensive HST/WFC3 emission-line studies, targeting two of the youngest and most rapidly evolving known PNe, NGC 7027 and NGC 6302. The resulting set of diagnostic emission-line (and line ratio) images will distinguish between photoionization and shock-induced ionization; between ionization fronts and conduction fronts; between active and "fossil" shaping processes; and between the action of intrinsic shaping engines (e.g., accretion-disk-driven jets) and extrinsic "pre-existing conditions" (e.g., AGB wind inhomogeneities and equatorial density enhancements).

## OBSERVING DESCRIPTION

Filter suite: We will obtain WFC3 images of each target PN in a dozen filters, notionally organized in these complementary filter sets:

- \* central star photoionization: [Ne IV] + [Ne V] (FQ243N + F343N)
- \* spatial variations of shocks vs. photoionization, optical: [O III] + [S II] + H $\alpha$  + H $\beta$  (F502N + F673N + F656N + F487N)
- \* spatial variations of shocks vs. photoionization, near-IR: [Fe II] + P $\beta$  (F164N/F167N + F128N/F130N)
- \* near-IR (scattered light) dust imaging: F110W + F160W

Exposure time and orbit requirements: The IUE-measured  $\lambda 2425$  [Ne IV] line fluxes of NGC 7027 and NGC 6302 are  $4 \times 10^{-13}$  and  $6 \times 10^{-14}$  erg cm $^{-2}$  s $^{-1}$ , respectively. ETC predicts 400 s exposure should reach S/N of 10 in a  $5 \times 5$  pixel region for FQ243N imaging of NGC 6302 given its line flux. Hence we can obtain high-quality images in this line and the  $\lambda 3426$  [Ne V] line (for which we assume similar line fluxes) in a single orbit dedicated to imaging of each PN in the FQ243N and F343N filters.

Typical maximum exposure times for both nebulae in previous observations through the optical filters that are repeated here (F502N, F656N, F673N; see "Duplications") are 400 s for NGC 7027 and 2200--5200 s for NGC 6302. Adopting similar maximum exposure times, and accounting for overheads and time required to obtain a suite of shorter (30--300 s) exposure times through each filter (thereby yielding images that are unsaturated even in the bright central regions of both nebulae), we require two orbits to cover the full optical filter set (F487N, F502N, F656N, F673N) for NGC

7027\footnote{Exposures of NGC 7027 with WFC3 through filters F487N, F502N, and F656N are included in a complementary Cycle 27 Treasury proposal, so we would drop the exposures of NGC 7027 through these 3 filters if the Treasury proposal is successful.} and three orbits to cover these same filters for NGC 6302.

For the near-IR image exposure times, the ETC predicts we can reach S/N of 10 in a  $5'' \times 5''$  pixel region in  $\sim 120$  s for F164N imaging of NGC 7027 given its measured total [Fe II]  $1.64 \mu\text{m}$  line flux of  $\sim 3 \times 10^{-14} \text{ erg cm}^{-2} \text{ s}^{-1}$ . This is similar to the times of archival (NICMOS) HST near-IR emission-line (H $_2$  and Br $\gamma$ ) imaging of this PN. As with these archival observations, we will perform on- and off-line imaging of [Fe II] and of ( $\sim 100$  times brighter) Pa $\beta$  so we can subtract continuum emission due to near-IR free-free radiation at the cores of each PN. These narrow-band near-IR observations, plus dust (scattered-light) imaging through the broad-band filters F110W and F160W, will require two orbits per PN.

We therefore request 5 and 6 orbits, respectively, for the proposed comprehensive WFC3 emission line imaging studies of NGC 7027 and NGC 6302.

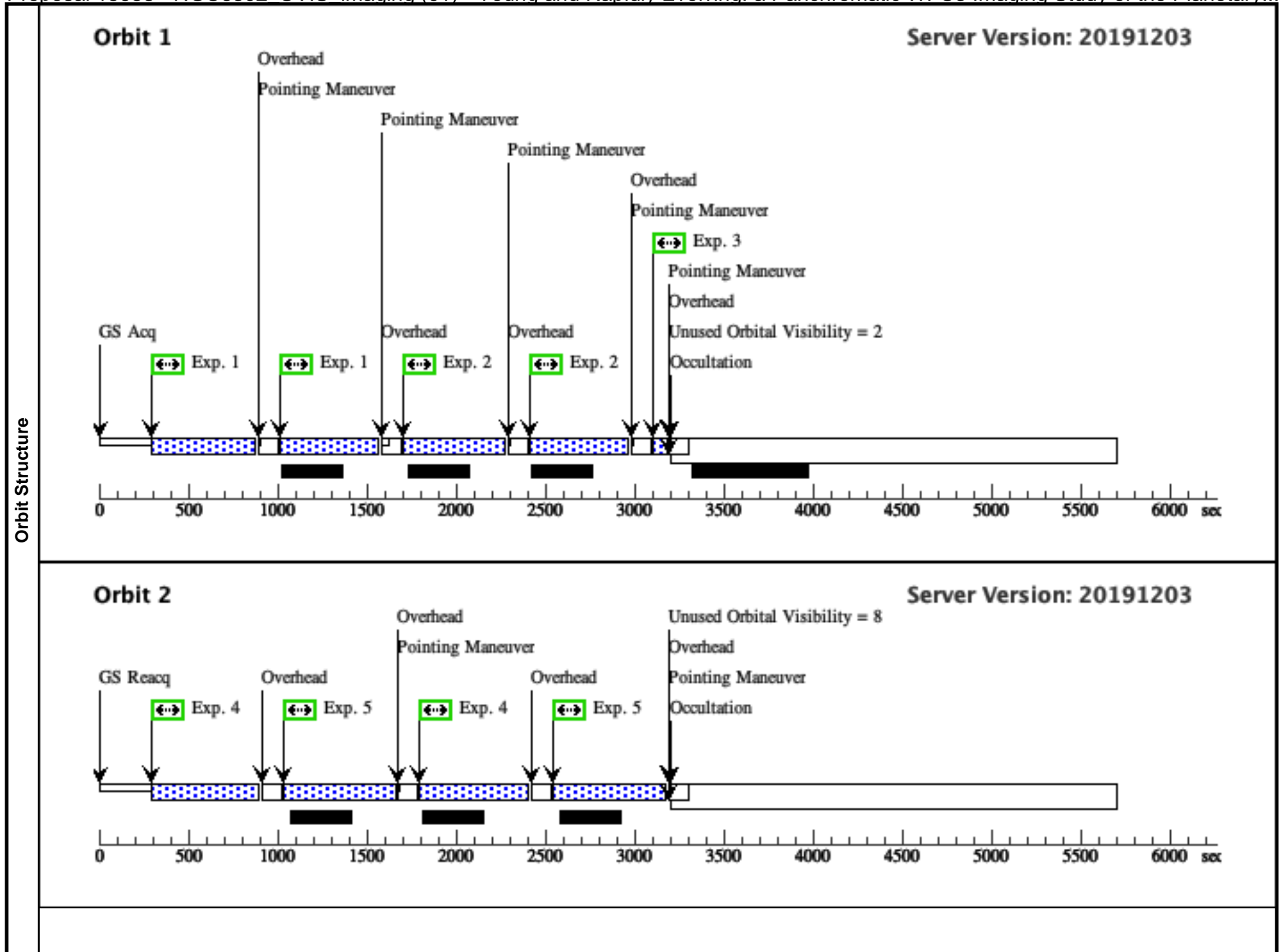
Proposal 15953 - NGC6302 UVIS imaging (01) - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary...

Fri Feb 14 21:00:24 GMT 2020

|                      |                                                                                                                                                                                                                                                                        |                                                                                                                        |                                                                                                        |                                 |                   |                         |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------|-------------------|-------------------------|
| <b>Visit</b>         | <b>Proposal 15953, NGC6302_UVIS_imaging (01), failed</b><br><b>Diagnostic Status: Warning</b><br>Scientific Instruments: WFC3/UVIS<br>Special Requirements: (none)<br><i>Comments: Perform UV (F0243N+F343N) and vis (F502N+F673N+F656N+F487N) imaging of NGC 6302</i> |                                                                                                                        |                                                                                                        |                                 |                   |                         |
|                      | (N6302_FQ243N (01.001)) Warning (Form): POS TARG & PATTERN should be used carefully with WFC3 quad filters to avoid placing the target on the vignetted part of the field of view or moving it to another quadrant.                                                    |                                                                                                                        |                                                                                                        |                                 |                   |                         |
| <b>Diagnosics</b>    |                                                                                                                                                                                                                                                                        |                                                                                                                        |                                                                                                        |                                 |                   |                         |
|                      |                                                                                                                                                                                                                                                                        |                                                                                                                        |                                                                                                        |                                 |                   |                         |
| <b>Patterns</b>      | <b>#</b>                                                                                                                                                                                                                                                               | <b>Primary Pattern</b>                                                                                                 | <b>Secondary Pattern</b>                                                                               | <b>Exposures</b>                |                   |                         |
|                      | (1)                                                                                                                                                                                                                                                                    | Pattern Type=WFC3-UVIS-DITHER-<br>LINE<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=0.145<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=46.84<br>Angle Between Sides=<br>Center Pattern=false |                                 | (1)               |                         |
|                      | (2)                                                                                                                                                                                                                                                                    | Pattern Type=WFC3-UVIS-GAP-LINE<br>Purpose=MOSAIC<br>Number Of Points=2<br>Point Spacing=2.414<br>Line Spacing=        | Coordinate Frame=POS-TARG<br>Pattern Orientation=85.759<br>Angle Between Sides=<br>Center Pattern=true |                                 | (2), (4-5), (7-8) |                         |
| <b>Fixed Targets</b> | <b>#</b>                                                                                                                                                                                                                                                               | <b>Name</b>                                                                                                            | <b>Target Coordinates</b>                                                                              | <b>Targ. Coord. Corrections</b> | <b>Fluxes</b>     | <b>Miscellaneous</b>    |
|                      | (2)                                                                                                                                                                                                                                                                    | NGC-6302                                                                                                               | RA: 17 13 44.3390 (258.4347458d)<br>Dec: -37 06 10.95 (-37.10304d)<br>Equinox: J2000                   | Epoch of Position: 2015.5       | V=10.1            | Reference Frame: SIMBAD |
|                      | <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i><br>Category=ISM<br>Description=[PLANETARY NEBULA]                                                                                                             |                                                                                                                        |                                                                                                        |                                 |                   |                         |

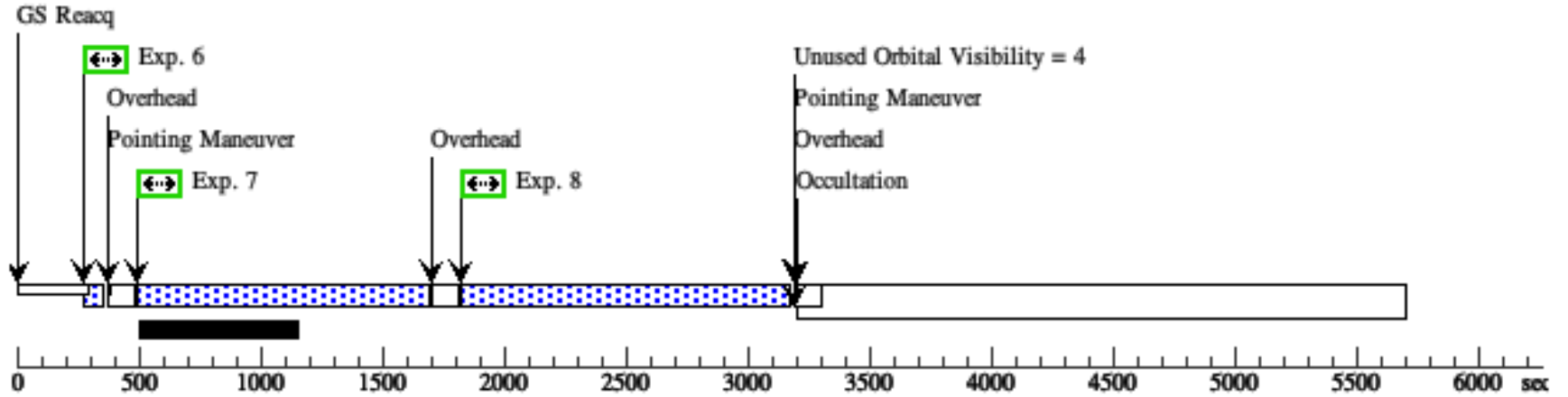
Proposal 15953 - NGC6302 UVIS imaging (01) - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary...

| Exposures | # | Label            | Target       | Config,Mode,Aperture           | Spectral Els. | Opt. Params. | Special Reqs. | Groups                                                       | Exp. Time (Total)/[Actual Dur.]                               | Orbit      |
|-----------|---|------------------|--------------|--------------------------------|---------------|--------------|---------------|--------------------------------------------------------------|---------------------------------------------------------------|------------|
|           | 1 | N6302_FQ2<br>43N | (2) NGC-6302 | WFC3/UVIS, ACCUM,<br>UVIS-QUAD | FQ243N        | FLASH=12     |               | Pattern 1, Exps 1-1 i<br>n NGC6302_UVIS_i<br>maging (01) (1) | 555 Secs (1110 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [1]        |
|           | 2 | N6302_F34<br>3N  | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F343N         | FLASH=10     |               | Pattern 2, Exps 2-2 i<br>n NGC6302_UVIS_i<br>maging (01) (2) | 555 Secs (1110 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [1]        |
|           | 3 | N6302_F65<br>6Ns | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F656N         | FLASH=12     |               |                                                              | 60 Secs (60 Secs)<br>[==>]                                    | [1]        |
|           | 4 | N6302_F65<br>6N  | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F656N         | FLASH=12     |               | Pattern 2, Exps 4-5 i<br>n NGC6302_UVIS_i<br>maging (01) (2) | 600 Secs (1200 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]        |
|           | 5 | N6302_F48<br>7N  | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F487N         | FLASH=10     |               | Pattern 2, Exps 4-5 i<br>n NGC6302_UVIS_i<br>maging (01) (2) | 600 Secs (1200 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]        |
|           | 6 | N6302_F50<br>2Ns | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F502N         | FLASH=12     |               |                                                              | 60 Secs (60 Secs)<br>[==>]                                    | [3]        |
|           | 7 | N6302_F50<br>2N  | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F502N         | FLASH=9      |               | Pattern 2, Exps 7-8 i<br>n NGC6302_UVIS_i<br>maging (01) (2) | 1200 Secs (2400 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [3]<br>[4] |
|           | 8 | N6302_F67<br>3N  | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F673N         | FLASH=8      |               | Pattern 2, Exps 7-8 i<br>n NGC6302_UVIS_i<br>maging (01) (2) | 1335 Secs (2670 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [3]<br>[4] |
|           | 9 | N6302_F67<br>3Ns | (2) NGC-6302 | WFC3/UVIS, ACCUM, UVIS-FIX     | F673N         | FLASH=12     |               |                                                              | 60 Secs (60 Secs)<br>[==>]                                    | [4]        |



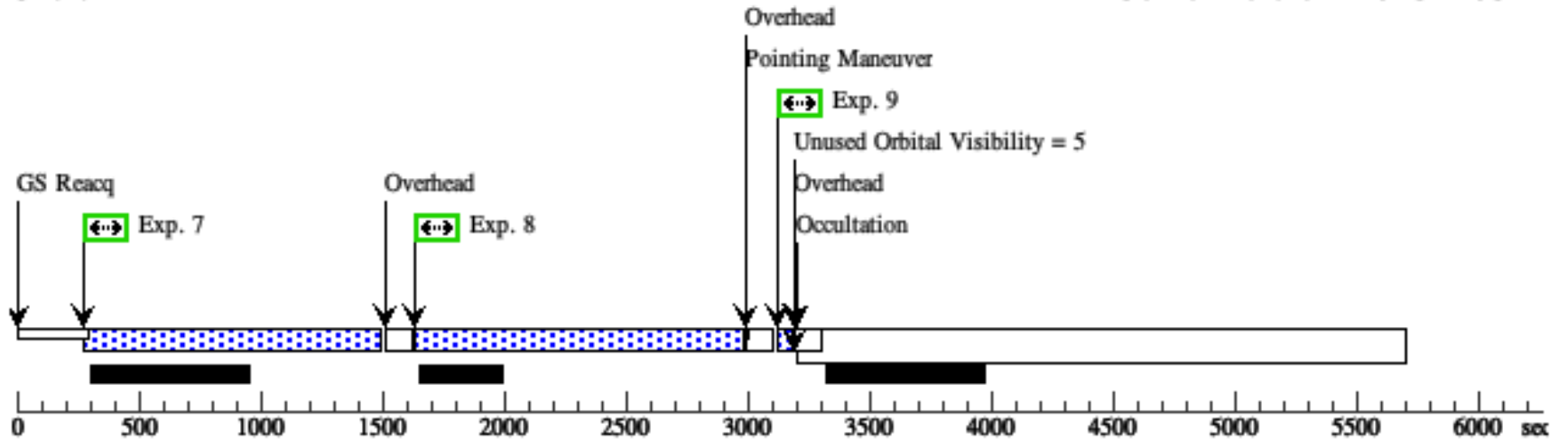
**Orbit 3**

Server Version: 20191203



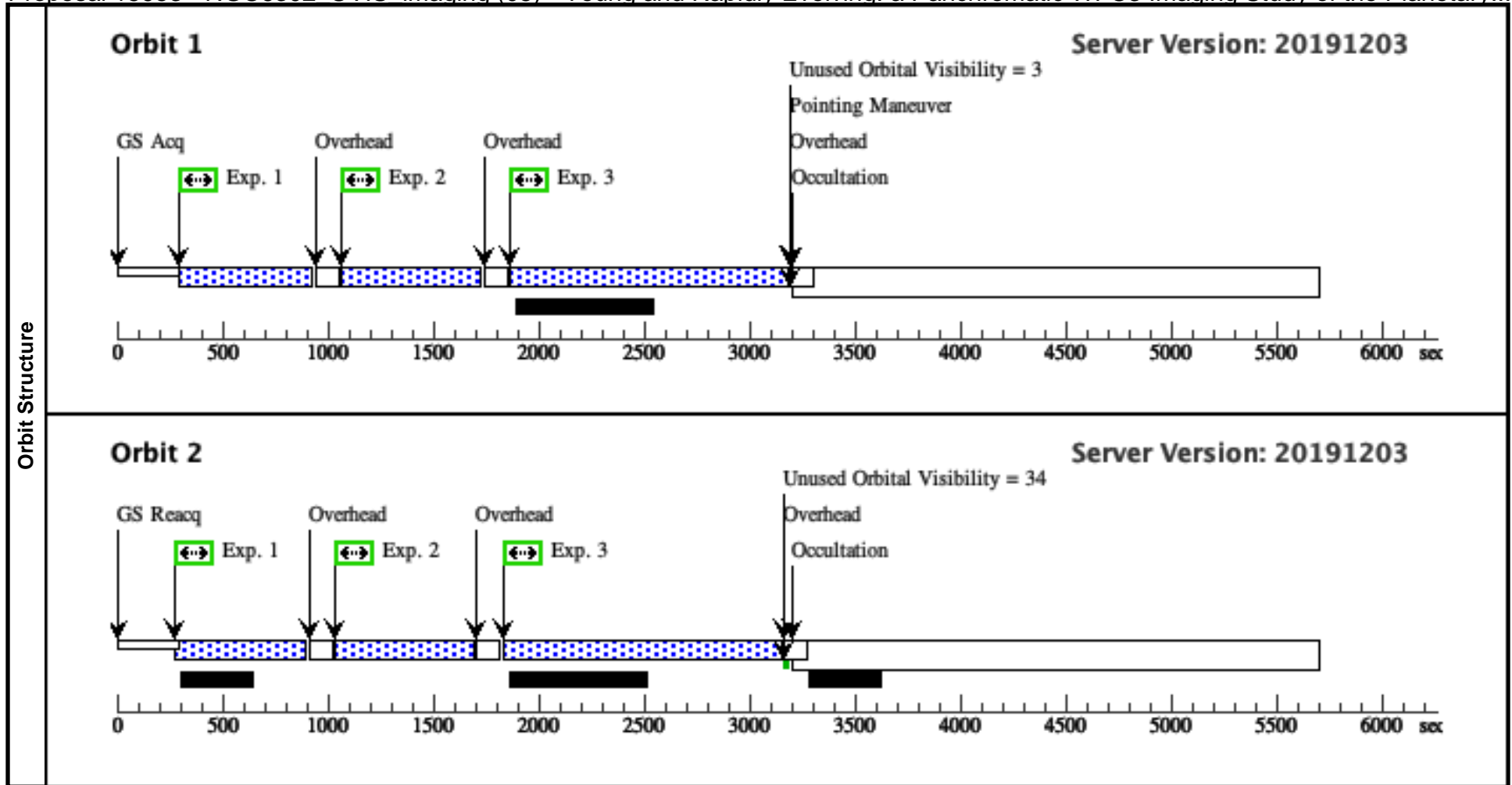
**Orbit 4**

Server Version: 20191203



Proposal 15953 - NGC6302 UVIS imaging (05) - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary...

|                      |                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                               |                                                                                      |                                 |                      |                         |                      |                                                              |                                                             |              |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------|----------------------|-------------------------|----------------------|--------------------------------------------------------------|-------------------------------------------------------------|--------------|
| <b>Visit</b>         | <b>Proposal 15953, NGC6302_UVIS_imaging (05)</b> <span style="float: right;">Fri Feb 14 21:00:25 GMT 2020</span><br><b>Diagnostic Status: No Diagnostics</b><br>Scientific Instruments: WFC3/UVIS<br>Special Requirements: (none)<br><i>Comments: Perform UV (F0243N+F343N) and vis (F502N+F673N+F656N+F487N) imaging of NGC 6302</i> |                                                                                                                                                                                                               |                                                                                      |                                 |                      |                         |                      |                                                              |                                                             |              |
|                      | <b>Patterns</b>                                                                                                                                                                                                                                                                                                                       | <b>#</b>                                                                                                                                                                                                      | <b>Primary Pattern</b>                                                               | <b>Secondary Pattern</b>        | <b>Exposures</b>     |                         |                      |                                                              |                                                             |              |
|                      | (2)                                                                                                                                                                                                                                                                                                                                   | Pattern Type=WFC3-UVIS-GAP-LINE Coordinate Frame=POS-TARG<br>Purpose=MOSAIC Pattern Orientation=85.759<br>Number Of Points=2 Angle Between Sides=<br>Point Spacing=2.414 Center Pattern=true<br>Line Spacing= |                                                                                      | (1-3)                           |                      |                         |                      |                                                              |                                                             |              |
| <b>Fixed Targets</b> | <b>#</b>                                                                                                                                                                                                                                                                                                                              | <b>Name</b>                                                                                                                                                                                                   | <b>Target Coordinates</b>                                                            | <b>Targ. Coord. Corrections</b> | <b>Fluxes</b>        | <b>Miscellaneous</b>    |                      |                                                              |                                                             |              |
|                      | (2)                                                                                                                                                                                                                                                                                                                                   | NGC-6302                                                                                                                                                                                                      | RA: 17 13 44.3390 (258.4347458d)<br>Dec: -37 06 10.95 (-37.10304d)<br>Equinox: J2000 | Epoch of Position: 2015.5       | V=10.1               | Reference Frame: SIMBAD |                      |                                                              |                                                             |              |
|                      | <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i><br>Category=ISM<br>Description=[PLANETARY NEBULA]                                                                                                                                                                            |                                                                                                                                                                                                               |                                                                                      |                                 |                      |                         |                      |                                                              |                                                             |              |
| <b>Exposures</b>     | <b>#</b>                                                                                                                                                                                                                                                                                                                              | <b>Label</b>                                                                                                                                                                                                  | <b>Target</b>                                                                        | <b>Config,Mode,Aperture</b>     | <b>Spectral Els.</b> | <b>Opt. Params.</b>     | <b>Special Reqs.</b> | <b>Groups</b>                                                | <b>Exp. Time (Total)/[Actual Dur.]</b>                      | <b>Orbit</b> |
|                      | 1                                                                                                                                                                                                                                                                                                                                     | N6302_F50<br>2N                                                                                                                                                                                               | (2) NGC-6302                                                                         | WFC3/UVIS, ACCUM, UVIS-FIX      | F502N                | FLASH=10                |                      | Pattern 2, Exps 1-3 i<br>n NGC6302_UVIS_i<br>maging (05) (2) | 600 Secs (1200 Secs)<br>[=>(Pattern 1)]<br>[=>(Pattern 2)]  | [1]<br>[2]   |
|                      | 2                                                                                                                                                                                                                                                                                                                                     | N6302_F67<br>3N                                                                                                                                                                                               | (2) NGC-6302                                                                         | WFC3/UVIS, ACCUM, UVIS-FIX      | F673N                | FLASH=9                 |                      | Pattern 2, Exps 1-3 i<br>n NGC6302_UVIS_i<br>maging (05) (2) | 645 Secs (1290 Secs)<br>[=>(Pattern 1)]<br>[=>(Pattern 2)]  | [1]<br>[2]   |
|                      | 3                                                                                                                                                                                                                                                                                                                                     | N6302_F65<br>8N                                                                                                                                                                                               | (2) NGC-6302                                                                         | WFC3/UVIS, ACCUM, UVIS-FIX      | F658N                | FLASH=9                 |                      | Pattern 2, Exps 1-3 i<br>n NGC6302_UVIS_i<br>maging (05) (2) | 1300 Secs (2600 Secs)<br>[=>(Pattern 1)]<br>[=>(Pattern 2)] | [1]<br>[2]   |

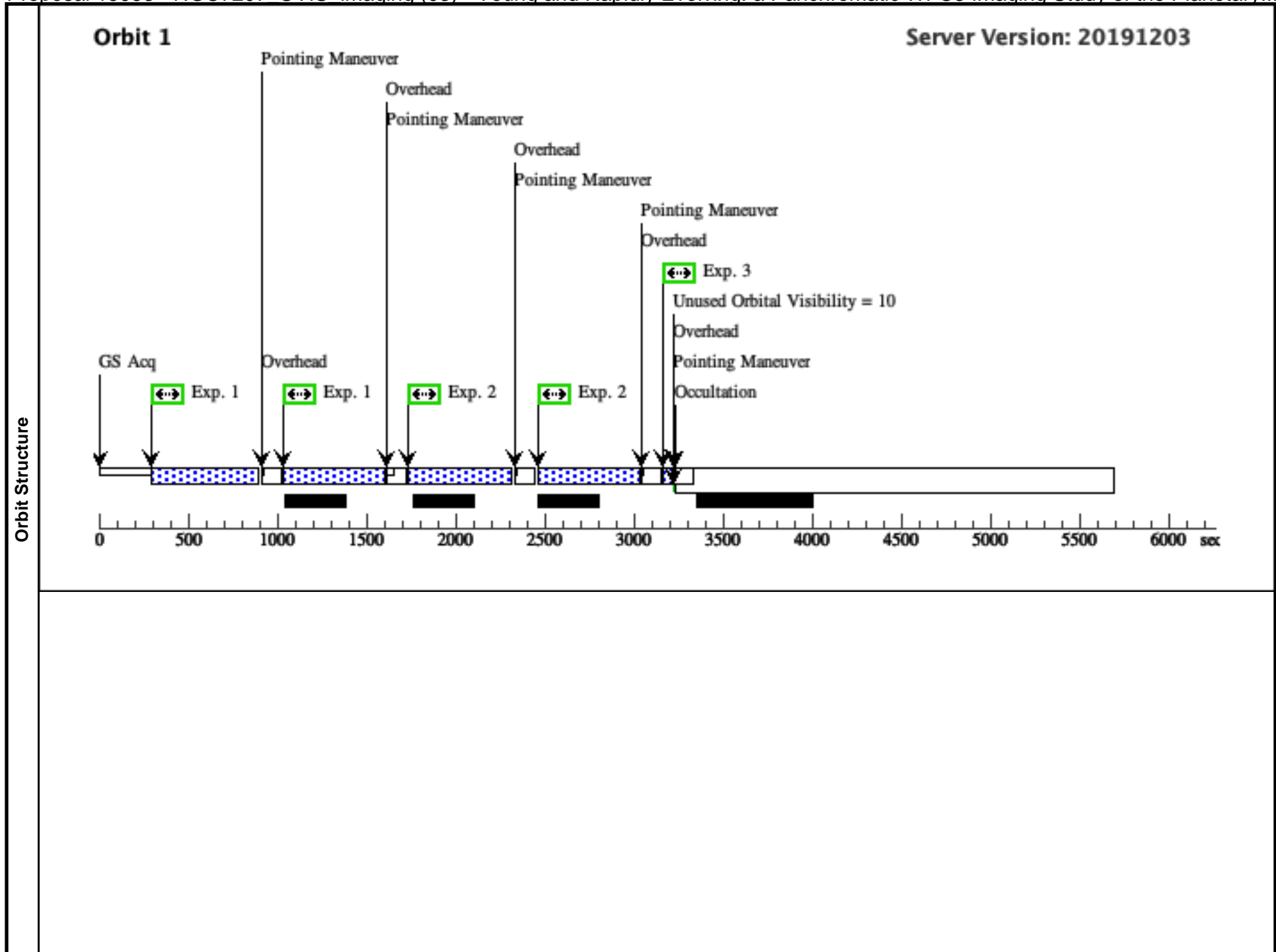


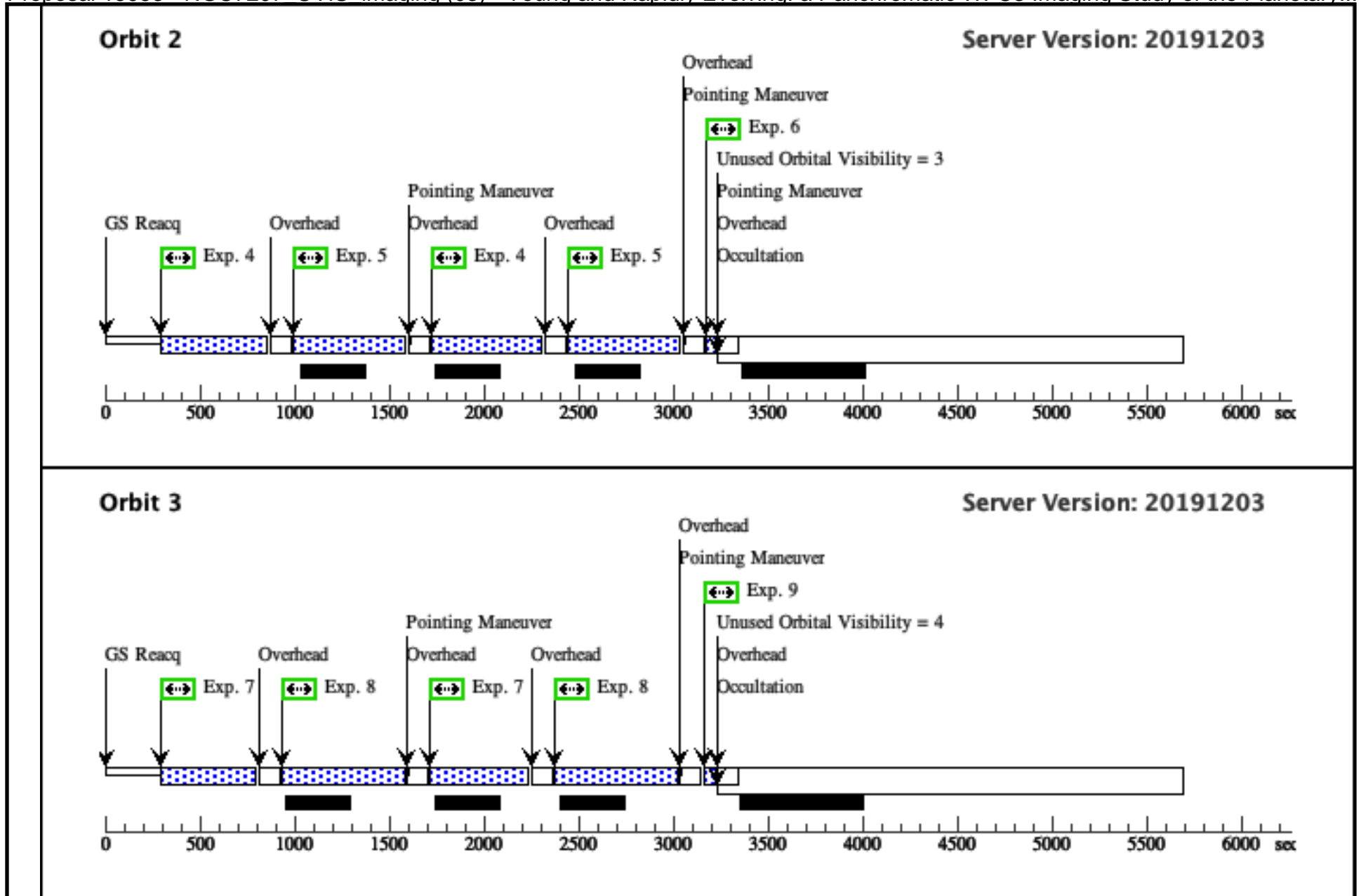
Proposal 15953 - NGC7207 UVIS imaging (03) - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary...

|                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                              |                                                                                    |                                                                                                                                               |               |                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------|
| <b>Visit</b>                                                                                                                                               | Proposal 15953, NGC7207_UVIS_imaging (03), completed <span style="float: right;">Fri Feb 14 21:00:25 GMT 2020</span><br><b>Diagnostic Status: Warning</b><br>Scientific Instruments: WFC3/UVIS<br>Special Requirements: (none)<br><i>Comments: Perform UV (F0243N+F343N) and vis (F502N+F673N+F656N+F487N) imaging of NGC 7027</i> |                                                                                                                                                                                                                              |                                                                                    |                                                                                                                                               |               |                         |
|                                                                                                                                                            | <b>Diagnosics</b><br>(N7027_FQ243N (03.001)) Warning (Form): POS TARG & PATTERN should be used carefully with WFC3 quad filters to avoid placing the target on the vignetted part of the field of view or moving it to another quadrant.                                                                                           |                                                                                                                                                                                                                              |                                                                                    |                                                                                                                                               |               |                         |
| <b>Patterns</b>                                                                                                                                            | <b>#</b>                                                                                                                                                                                                                                                                                                                           | <b>Primary Pattern</b>                                                                                                                                                                                                       | <b>Secondary Pattern</b>                                                           | <b>Exposures</b>                                                                                                                              |               |                         |
|                                                                                                                                                            | (1)                                                                                                                                                                                                                                                                                                                                | Pattern Type=WFC3-UVIS-DITHER-LINE<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=0.145<br>Line Spacing=<br>Coordinate Frame=POS-TARG<br>Pattern Orientation=46.84<br>Angle Between Sides=<br>Center Pattern=false |                                                                                    | (1)                                                                                                                                           |               |                         |
| (2)                                                                                                                                                        | Pattern Type=WFC3-UVIS-GAP-LINE<br>Purpose=MOSAIC<br>Number Of Points=2<br>Point Spacing=2.414<br>Line Spacing=<br>Coordinate Frame=POS-TARG<br>Pattern Orientation=85.759<br>Angle Between Sides=<br>Center Pattern=true                                                                                                          |                                                                                                                                                                                                                              | (2), (4-5), (7-8)                                                                  |                                                                                                                                               |               |                         |
| <b>Fixed Targets</b>                                                                                                                                       | <b>#</b>                                                                                                                                                                                                                                                                                                                           | <b>Name</b>                                                                                                                                                                                                                  | <b>Target Coordinates</b>                                                          | <b>Targ. Coord. Corrections</b>                                                                                                               | <b>Fluxes</b> | <b>Miscellaneous</b>    |
|                                                                                                                                                            | (1)                                                                                                                                                                                                                                                                                                                                | NGC-7027                                                                                                                                                                                                                     | RA: 21 07 1.8000 (316.7575000d)<br>Dec: +42 14 10.00 (42.23611d)<br>Equinox: J2000 | Proper Motion RA: 5.402623112538935E-4<br>sec of time/yr<br>Proper Motion Dec: -0.01600000009602809<br>arcsec/yr<br>Epoch of Position: 2015.5 | V=10.9        | Reference Frame: SIMBAD |
| <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i><br>Category=ISM<br>Description=[PLANETARY NEBULA] |                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                              |                                                                                    |                                                                                                                                               |               |                         |

Proposal 15953 - NGC7207 UVIS imaging (03) - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary...

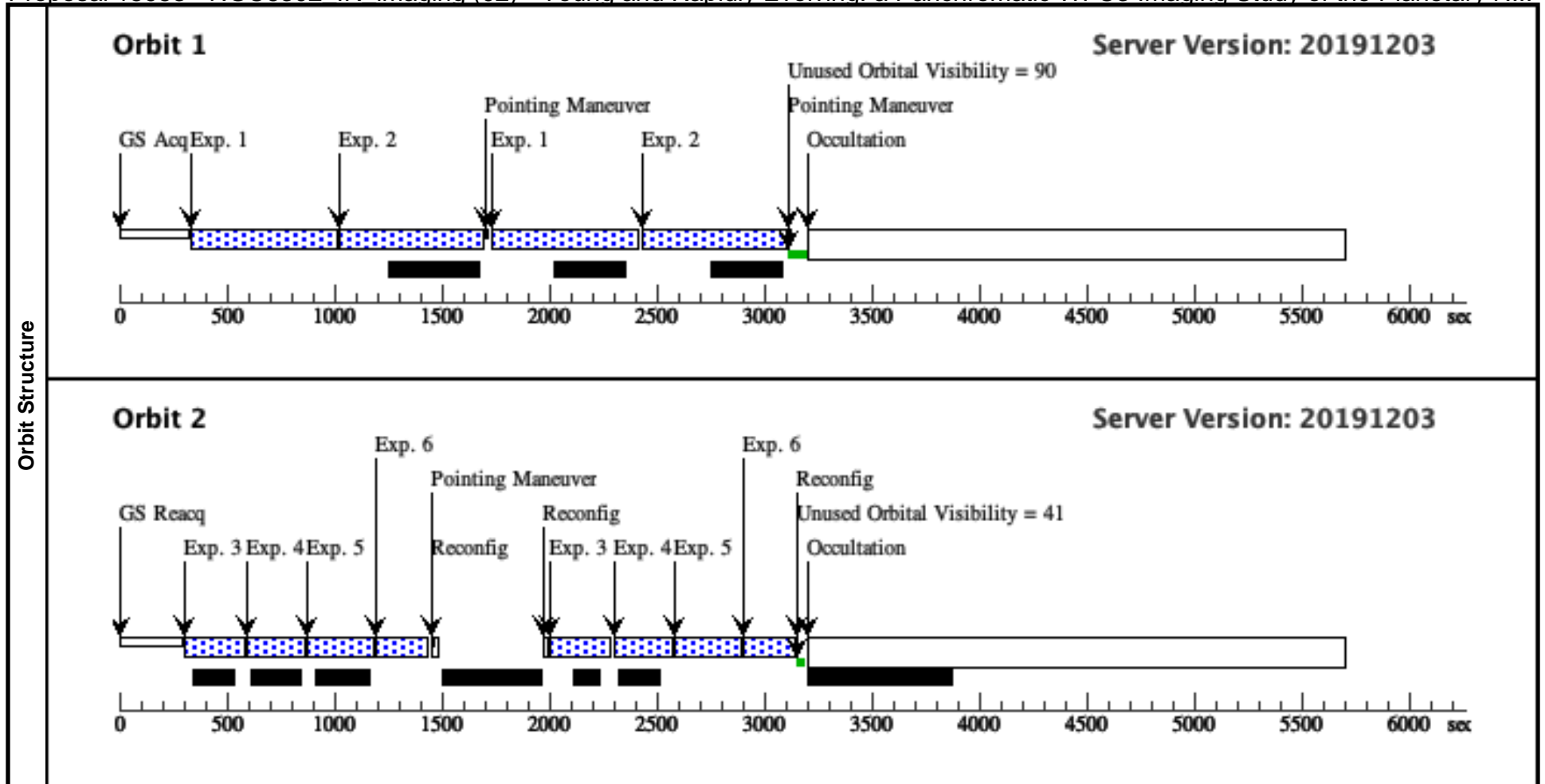
| Exposures | # | Label            | Target       | Config,Mode,Aperture           | Spectral Els. | Opt. Params. | Special Reqs. | Groups                                                       | Exp. Time (Total)/[Actual Dur.]                              | Orbit |
|-----------|---|------------------|--------------|--------------------------------|---------------|--------------|---------------|--------------------------------------------------------------|--------------------------------------------------------------|-------|
|           | 1 | N7027_FQ2<br>43N | (1) NGC-7027 | WFC3/UVIS, ACCUM,<br>UVIS-QUAD | FQ243N        | FLASH=12     |               | Pattern 1, Exps 1-1 i<br>n NGC7207_UVIS_i<br>maging (03) (1) | 570 Secs (1140 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [1]   |
|           | 2 | N7027_F34<br>3N  | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F343N         | FLASH=10     |               | Pattern 2, Exps 2-2 i<br>n NGC7207_UVIS_i<br>maging (03) (2) | 570 Secs (1140 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [1]   |
|           | 3 | N7027_F65<br>6Ns | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F656N         | FLASH=12     |               |                                                              | 30 Secs (30 Secs)<br>[==>]                                   | [1]   |
|           | 4 | N7027_F65<br>6N  | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F656N         | FLASH=12     |               | Pattern 2, Exps 4-5 i<br>n NGC7207_UVIS_i<br>maging (03) (2) | 565 Secs (1130 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [2]   |
|           | 5 | N7027_F48<br>7N  | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F487N         | FLASH=10     |               | Pattern 2, Exps 4-5 i<br>n NGC7207_UVIS_i<br>maging (03) (2) | 565 Secs (1130 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [2]   |
|           | 6 | N7027_F50<br>2Ns | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F502N         | FLASH=12     |               |                                                              | 30 Secs (30 Secs)<br>[==>]                                   | [2]   |
|           | 7 | N7027_F50<br>2N  | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F502N         | FLASH=10     |               | Pattern 2, Exps 7-8 i<br>n NGC7207_UVIS_i<br>maging (03) (2) | 500 Secs (1000 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [3]   |
|           | 8 | N7027_F67<br>3N  | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F673N         | FLASH=10     |               | Pattern 2, Exps 7-8 i<br>n NGC7207_UVIS_i<br>maging (03) (2) | 630 Secs (1260 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [3]   |
|           | 9 | N7027_F67<br>3Ns | (1) NGC-7027 | WFC3/UVIS, ACCUM, UVIS-FIX     | F673N         | FLASH=12     |               |                                                              | 60 Secs (60 Secs)<br>[==>]                                   | [3]   |





Proposal 15953 - NGC6302 IR imaging (02) - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary N...

| Visit         | <b>Proposal 15953, NGC6302_IR_imaging (02), completed</b> <span style="float: right;">Fri Feb 14 21:00:25 GMT 2020</span><br><b>Diagnostic Status: No Diagnostics</b><br>Scientific Instruments: WFC3/IR<br>Special Requirements: (none)<br><i>Comments: Imaging of NGC 6302 with near-IR narrow-band filters (F164N, F167N, F128N) and broad-band filters (F110W, F160W)</i> |                                                                                                                  |                                                                                                        |                             |               |                                   |               |                                                    |                                                                         |       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------|---------------|-----------------------------------|---------------|----------------------------------------------------|-------------------------------------------------------------------------|-------|
|               | Patterns                                                                                                                                                                                                                                                                                                                                                                      | #                                                                                                                | Primary Pattern                                                                                        | Secondary Pattern           | Exposures     |                                   |               |                                                    |                                                                         |       |
|               | (3)                                                                                                                                                                                                                                                                                                                                                                           | Pattern Type=WFC3-IR-DITHER-BLOB<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=5.183<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=41.859<br>Angle Between Sides=<br>Center Pattern=true |                             | (1-2), (3-6)  |                                   |               |                                                    |                                                                         |       |
| Fixed Targets | #                                                                                                                                                                                                                                                                                                                                                                             | Name                                                                                                             | Target Coordinates                                                                                     | Targ. Coord. Corrections    | Fluxes        | Miscellaneous                     |               |                                                    |                                                                         |       |
|               | (2)                                                                                                                                                                                                                                                                                                                                                                           | NGC-6302                                                                                                         | RA: 17 13 44.3390 (258.4347458d)<br>Dec: -37 06 10.95 (-37.10304d)<br>Equinox: J2000                   | Epoch of Position: 2015.5   | V=10.1        | Reference Frame: SIMBAD           |               |                                                    |                                                                         |       |
|               | <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i><br>Category=ISM<br>Description=[PLANETARY NEBULA]                                                                                                                                                                                                                    |                                                                                                                  |                                                                                                        |                             |               |                                   |               |                                                    |                                                                         |       |
| Exposures     | #                                                                                                                                                                                                                                                                                                                                                                             | Label                                                                                                            | Target                                                                                                 | Config,Mode,Aperture        | Spectral Els. | Opt. Params.                      | Special Reqs. | Groups                                             | Exp. Time (Total)/[Actual Dur.]                                         | Orbit |
|               | 1                                                                                                                                                                                                                                                                                                                                                                             | N6302_F16<br>4N                                                                                                  | (2) NGC-6302                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX | F164N         | NSAMP=14;<br>SAMP-SEQ=SPAR<br>S50 |               | Pattern 3, Exps 1-2 in NGC6302_IR_imaging (02) (3) | 652.938154 Secs (1305.876 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [1]   |
|               | 2                                                                                                                                                                                                                                                                                                                                                                             | N6302_F16<br>7N                                                                                                  | (2) NGC-6302                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX | F167N         | NSAMP=14;<br>SAMP-SEQ=SPAR<br>S50 |               | Pattern 3, Exps 1-2 in NGC6302_IR_imaging (02) (3) | 652.938154 Secs (1305.876 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [1]   |
|               | 3                                                                                                                                                                                                                                                                                                                                                                             | N6302_F12<br>8N                                                                                                  | (2) NGC-6302                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX | F128N         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=11 |               | Pattern 3, Exps 3-6 in NGC6302_IR_imaging (02) (3) | 252.937441 Secs (505.875 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |
|               | 4                                                                                                                                                                                                                                                                                                                                                                             | N6302_F13<br>0N                                                                                                  | (2) NGC-6302                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX | F130N         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=11 |               | Pattern 3, Exps 3-6 in NGC6302_IR_imaging (02) (3) | 252.937441 Secs (505.875 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |
|               | 5                                                                                                                                                                                                                                                                                                                                                                             | N6302_F11<br>0W                                                                                                  | (2) NGC-6302                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX | F110W         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=12 |               | Pattern 3, Exps 3-6 in NGC6302_IR_imaging (02) (3) | 277.937956 Secs (555.876 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |
|               | 6                                                                                                                                                                                                                                                                                                                                                                             | N6302_F16<br>0W                                                                                                  | (2) NGC-6302                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX | F160W         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=10 |               | Pattern 3, Exps 3-6 in NGC6302_IR_imaging (02) (3) | 227.936926 Secs (455.874 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |



Proposal 15953 - NGC7027 IR imaging (04) - Young and Rapidly Evolving: a Panchromatic WFC3 Imaging Study of the Planetary N...

| Visit         | <b>Proposal 15953, NGC7027_IR_imaging (04), completed</b> <span style="float: right;">Fri Feb 14 21:00:25 GMT 2020</span><br><b>Diagnostic Status: No Diagnostics</b><br>Scientific Instruments: WFC3/IR<br>Special Requirements: (none)<br><i>Comments: Imaging of NGC 7027 with near-IR narrow-band filters (F164N, F167N, F128N) and broad-band filters (F110W, F160W)</i> |                                                                                                                  |                                                                                                        |                                                                                                                                               |               |                                   |               |                                                    |                                                                         |       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------------------------|---------------|----------------------------------------------------|-------------------------------------------------------------------------|-------|
|               | Patterns                                                                                                                                                                                                                                                                                                                                                                      | #                                                                                                                | Primary Pattern                                                                                        | Secondary Pattern                                                                                                                             | Exposures     |                                   |               |                                                    |                                                                         |       |
|               | (3)                                                                                                                                                                                                                                                                                                                                                                           | Pattern Type=WFC3-IR-DITHER-BLOB<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=5.183<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=41.859<br>Angle Between Sides=<br>Center Pattern=true |                                                                                                                                               | (1-2), (3-6)  |                                   |               |                                                    |                                                                         |       |
| Fixed Targets | #                                                                                                                                                                                                                                                                                                                                                                             | Name                                                                                                             | Target Coordinates                                                                                     | Targ. Coord. Corrections                                                                                                                      | Fluxes        | Miscellaneous                     |               |                                                    |                                                                         |       |
|               | (1)                                                                                                                                                                                                                                                                                                                                                                           | NGC-7027                                                                                                         | RA: 21 07 1.8000 (316.7575000d)<br>Dec: +42 14 10.00 (42.23611d)<br>Equinox: J2000                     | Proper Motion RA: 5.402623112538935E-4<br>sec of time/yr<br>Proper Motion Dec: -0.01600000009602809<br>arcsec/yr<br>Epoch of Position: 2015.5 | V=10.9        | Reference Frame: SIMBAD           |               |                                                    |                                                                         |       |
|               | <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i><br>Category=ISM<br>Description=[PLANETARY NEBULA]                                                                                                                                                                                                                    |                                                                                                                  |                                                                                                        |                                                                                                                                               |               |                                   |               |                                                    |                                                                         |       |
| Exposures     | #                                                                                                                                                                                                                                                                                                                                                                             | Label                                                                                                            | Target                                                                                                 | Config,Mode,Aperture                                                                                                                          | Spectral Els. | Opt. Params.                      | Special Reqs. | Groups                                             | Exp. Time (Total)/[Actual Dur.]                                         | Orbit |
|               | 1                                                                                                                                                                                                                                                                                                                                                                             | N7027_F16<br>4N                                                                                                  | (1) NGC-7027                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX                                                                                                                   | F164N         | NSAMP=14;<br>SAMP-SEQ=SPAR<br>S50 |               | Pattern 3, Exps 1-2 in NGC7027_IR_imaging (04) (3) | 652.938154 Secs (1305.876 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [1]   |
|               | 2                                                                                                                                                                                                                                                                                                                                                                             | N7027_F16<br>7N                                                                                                  | (1) NGC-7027                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX                                                                                                                   | F167N         | NSAMP=14;<br>SAMP-SEQ=SPAR<br>S50 |               | Pattern 3, Exps 1-2 in NGC7027_IR_imaging (04) (3) | 652.938154 Secs (1305.876 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)] | [1]   |
|               | 3                                                                                                                                                                                                                                                                                                                                                                             | N7027_F12<br>8N                                                                                                  | (1) NGC-7027                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX                                                                                                                   | F128N         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=11 |               | Pattern 3, Exps 3-6 in NGC7027_IR_imaging (04) (3) | 252.937441 Secs (505.875 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |
|               | 4                                                                                                                                                                                                                                                                                                                                                                             | N7027_F13<br>0N                                                                                                  | (1) NGC-7027                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX                                                                                                                   | F130N         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=11 |               | Pattern 3, Exps 3-6 in NGC7027_IR_imaging (04) (3) | 252.937441 Secs (505.875 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |
|               | 5                                                                                                                                                                                                                                                                                                                                                                             | N7027_F11<br>0W                                                                                                  | (1) NGC-7027                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX                                                                                                                   | F110W         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=12 |               | Pattern 3, Exps 3-6 in NGC7027_IR_imaging (04) (3) | 277.937956 Secs (555.876 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |
|               | 6                                                                                                                                                                                                                                                                                                                                                                             | N7027_F16<br>0W                                                                                                  | (1) NGC-7027                                                                                           | WFC3/IR, MULTIACCUM, IR-FIX                                                                                                                   | F160W         | SAMP-SEQ=SPARS<br>25;<br>NSAMP=10 |               | Pattern 3, Exps 3-6 in NGC7027_IR_imaging (04) (3) | 227.936926 Secs (455.874 Secs)<br>[==>(Pattern 1)]<br>[==>(Pattern 2)]  | [2]   |

