# 16785 - A Multi-Cycle Monitoring Program of the Hydra's Shadow

Cycle: 29, Proposal Category: GO

(Availability Mode: SUPPORTED)

**INVESTIGATORS**

| *Name* | *Institution* |
|---|---|
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| Dr. Rebecca Nealon (CoI) (ESA Member) | The University of Warwick |
| Dr. Richard Alexander (CoI) (ESA Member) | University of Leicester |
| Prof. Sarah Elaine Dodson-Robinson (CoI) | University of Delaware |

**VISITS**

| *Visit* | *Targets used in Visit* | *Configurations used in Visit* | *Orbits Used* | *Last Orbit Planner Run* | *OP Current with Visit?* |
|---|---|---|---|---|---|
| 01 | (1) V-TW-HYA | STIS/CCD | 1 | 07-Sep-2023 19:00:19.0 | yes |
| 02 | (1) V-TW-HYA | STIS/CCD | 1 | 07-Sep-2023 19:00:20.0 | yes |
| 03 | (2) PSF-REF-HD85512 | STIS/CCD | 1 | 07-Sep-2023 19:00:22.0 | yes |
| 04 | (1) V-TW-HYA | STIS/CCD | 1 | 07-Sep-2023 19:00:23.0 | yes |

4 Total Orbits Used

**ABSTRACT**

In the era of HST, JWST, and ALMA, the initial conditions of planet formation will be laid bare through the direct imaging of planet forming regions around nearby young stars. As more and more disks are observed over multiple epochs, their dynamic and variable natures are revealed, opening new avenues of study. Archival HST images of TW Hya's outer disk show that it has a shadow that orbits with a period of ~16 yr, but the full orbit of the shadow has not been observed, leaving ambiguity about its origin. We propose to observe TW Hya over the next three Cycles with HST/STIS coronagraphy to fill in badly needed orbital phase coverage of the shadow's motion and create a homogenous, high quality dataset with archival STIS observations. Our program will elucidate the physical origin of the shadow and constrain the structure of TW Hya's inner cavity independently from sub-mm imaging. Disk shadow imaging is a new tool for understanding the initial conditions of planet formation at radii inaccessible by other observations.

**OBSERVING DESCRIPTION**

This proposal is replicated from 16228, which observed TW Hya in 2021 with a combination of BAR5 and WEDGEA1.0 50CORON aperture positions. In this program we observe TW HYA in 3 visits interleaved with one visit of the PSF star. The first and last visit of TW Hya is oriented off nominal of between +/-15 to +/-30 degrees to enhance angular coverage of the protoplanetary disk. We seek to have this visit scheduled at some point during Cycle 29 so as to cover new phases of the shadow's behavior.

## Visit

**Proposal 16785, V1-TWHYA (01), completed** Thu Sep 07 23:00:23 GMT 2023

**Diagnostic Status: Warning**

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; GUID TOL 0.005"; GYRO MODE 3GOBAD; SCHED 100%; ORIENT -30D TO -15D FROM 02

*Comments: TW Hya*
*First of two sets of visits, each containing three visits of TW Hya at different relative orientations with one PSF calibration observation interleaved.*
*This is the first TW Hya visit in the first set.*
*The four visits within each set must be executed sequentially in contiguous orbits interrupted only for Earth occultation.*

*Orientation: We wish to schedule this visit (1) at -30 deg from Visit 2, with the absolute orientation of Visit 2 unconstrained.*
*We allow a relative orientation tolerence from -15 deg to -30 deg to assist in guide star selection and scheduling.*
*NOTE to PC: Schedule as close to -30 deg from Visit 2 as possible.*

*Relative Timing: This visit (1) should immediately preceed visit (2). I.e., They should be executed sequentially in "back-to-back" orbits.*

*BAR5 exposure times are selected to maximize SNR close to the star (~10-15/pixel up to inner working angle) and WEDGEA1.0 are selected to be as long as possible to ensure depth exterior to 1".*

## Diagnostics

(V1-TWHYA (01)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

## Fixed Targets

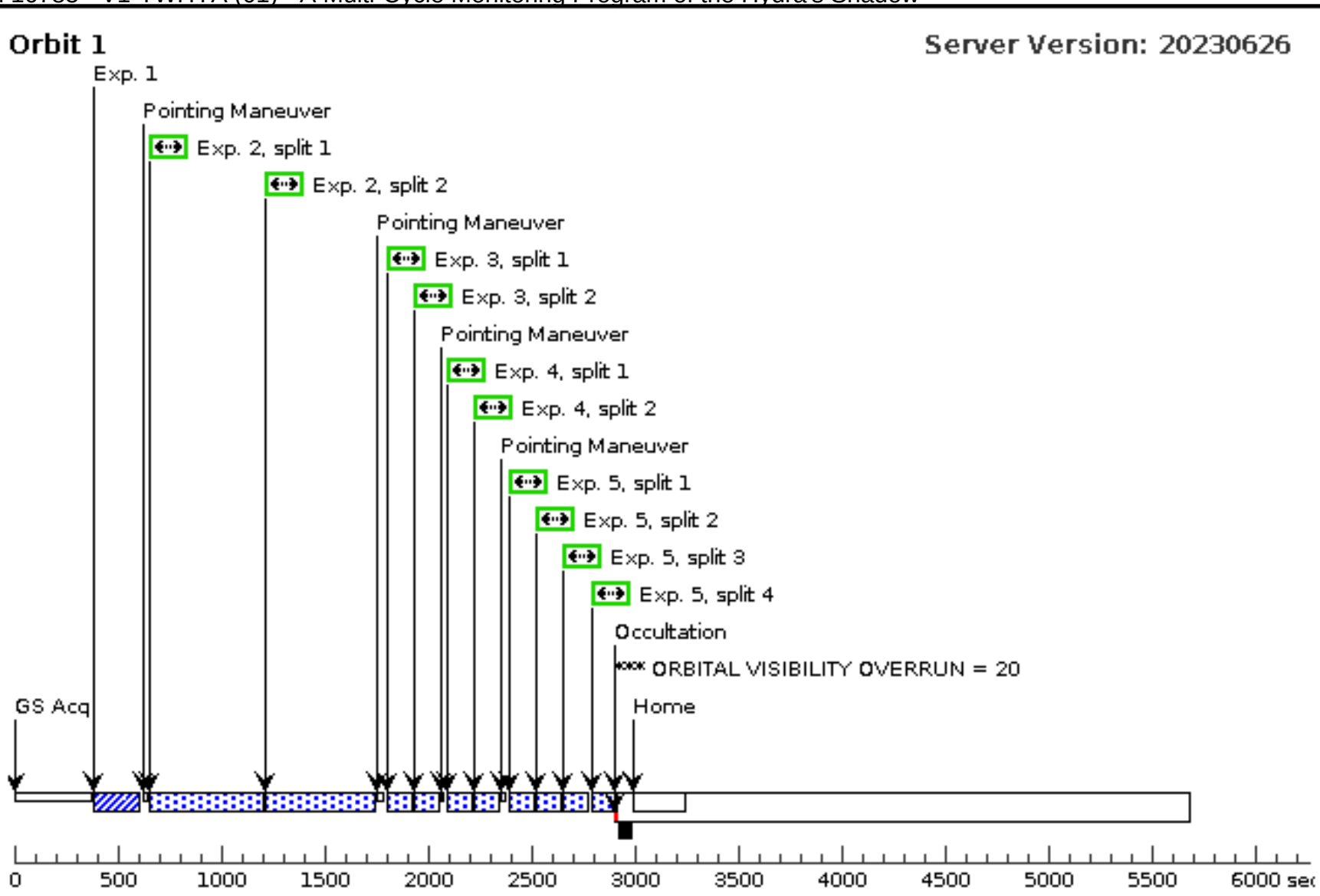
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | V-TW-HYA | RA: 11 01 51.9129 (165.4663038d)<br>Dec: -34 42 17.00 (-34.70472d)<br>Equinox: J2000 | Proper Motion RA: -68.4 mas/yr<br>Proper Motion Dec: -14.02 mas/yr<br>Epoch of Position: 1999.32 | V=10.5 | Reference Frame: ICRS |

*Comments:*
*Category=STAR*
*Description=[T TAURI STAR]*
*Extended=NO*

## Exposures

| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | TWHYA_ACQ (STIS.ta.1447817) | (1) V-TW-HYA | STIS/CCD, ACQ, F28X50LP | MIRROR | | GS ACQ SCENARIO BASE1B3 | Sequence 1-5 Non-Int in V1-TWHYA (01) | 0.2 Secs (0.2 Secs)<br>*[==>]* | ***[1]*** |
| 2 | TWHYA_LONG_1 | (1) V-TW-HYA | STIS/CCD, ACCUM, WEDGEA1.0 | MIRROR | SIZEAXIS2=427;<br>CR-SPLIT=2;<br>GAIN=4 | | Sequence 1-5 Non-Int in V1-TWHYA (01) | 1016 Secs (1016 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | ***[1]*** |
| 3 | TWHYA_BAR10_LL | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=2;<br>GAIN=4 | POS TARG -1.23270,-1.30535 | Sequence 1-5 Non-Int in V1-TWHYA (01) | 220 Secs (220 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | ***[1]*** |
| 4 | TWHYA_BAR10_LR | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=2;<br>GAIN=4 | POS TARG 1.33805,-1.30016 | Sequence 1-5 Non-Int in V1-TWHYA (01) | 220 Secs (220 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | ***[1]*** |
| 5 | TWHYA_BAR5_CENTER | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR5 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=4;<br>GAIN=4 | | Sequence 1-5 Non-Int in V1-TWHYA (01) | 440 Secs (440 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]* | ***[1]*** |

Orbit Structure



## Visit

**Proposal 16785, V2-TWHYA (02), completed** Thu Sep 07 23:00:24 GMT 2023

**Diagnostic Status: Warning**

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; GUID TOL 0.005"; GYRO MODE 3GOBAD; SCHED 100%; AFTER 01 BY .5 Orbits TO 1.5 Orbits

*Comments: TW Hya*
*three visits of TW HYA at different relative orientations with one PSF calibration observation interleaved.*
*This is the second TW Hya visit in the first set.*
*The four visits within the set must be executed sequentially in contiguous orbits interrupted only for Earth occultation.*

*Orientation: There are no orientation constraints on this visit (2).*
*This visit at nominal roll as scheduled by STScI.*
*Visits 1, 3, 4 carry relative orientation constraints w.r.t. this visit.*

*Relative Timing: This visit (2) should immediately follow Visit 1 and immediately preceed Visit 3 in back-to-back orbits.*

## Diagnostics

(V2-TWHYA (02)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

## Fixed Targets

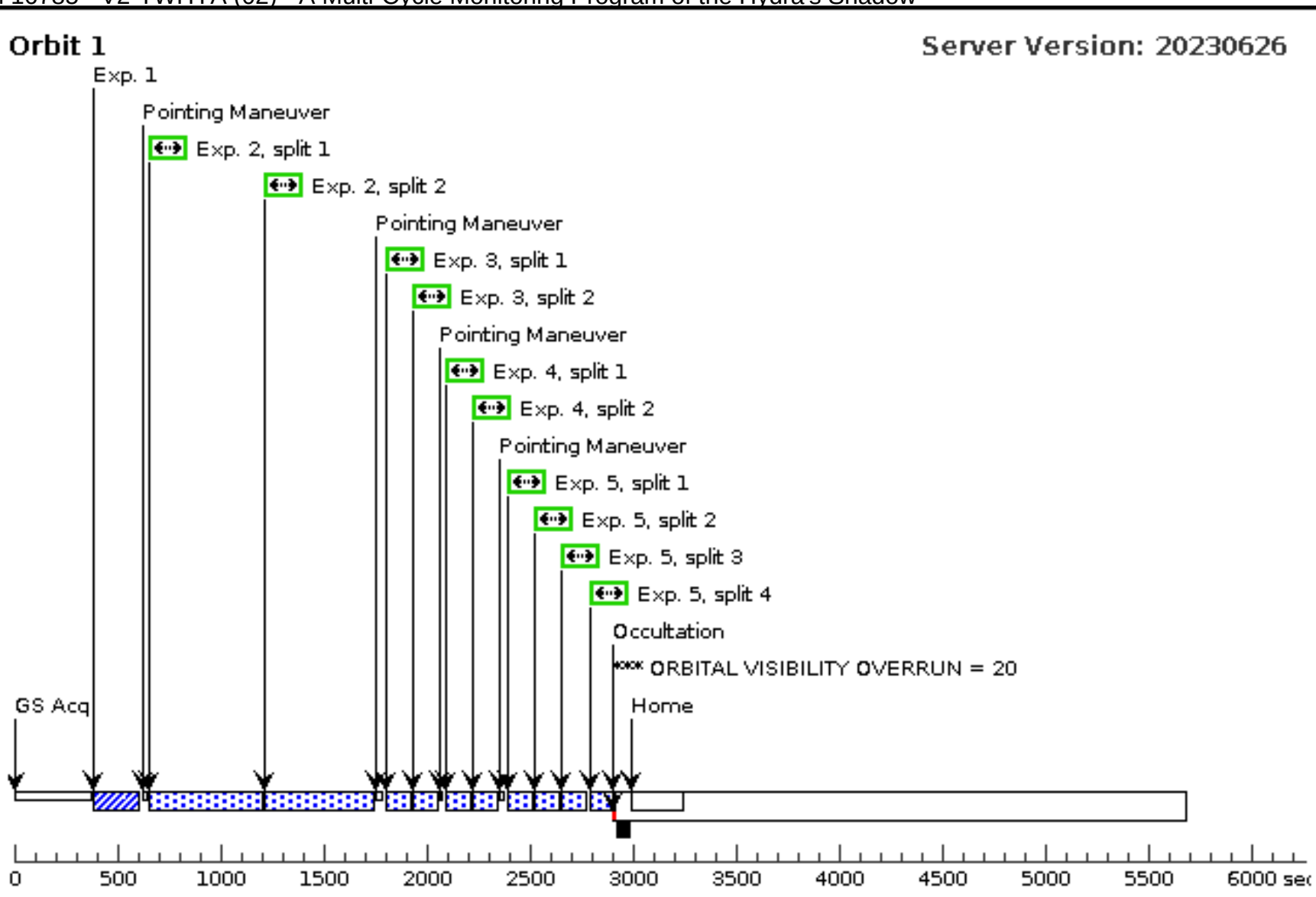
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | V-TW-HYA | RA: 11 01 51.9129 (165.4663038d)<br>Dec: -34 42 17.00 (-34.70472d)<br>Equinox: J2000 | Proper Motion RA: -68.4 mas/yr<br>Proper Motion Dec: -14.02 mas/yr<br>Epoch of Position: 1999.32 | V=10.5 | Reference Frame: ICRS |

*Comments:*
*Category=STAR*
*Description=[T TAURI STAR]*
*Extended=NO*

## Exposures

| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | TWHYA_ACQ (STIS.ta.1447817) | (1) V-TW-HYA | STIS/CCD, ACQ, F28X50LP | MIRROR | | GS ACQ SCENARIO BASE1B3 | Sequence 1-5 Non-Int in V2-TWHYA (02) | .2 Secs (0.2 Secs)<br>*[==>]* | *[1]* |
| 2 | TWHYA_LONG_1 | (1) V-TW-HYA | STIS/CCD, ACCUM, WEDGEA1.0 | MIRROR | SIZEAXIS2=427;<br>CR-SPLIT=2;<br>GAIN=4 | | Sequence 1-5 Non-Int in V2-TWHYA (02) | 1016 Secs (1016 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | *[1]* |
| 3 | TWHYA_BAR10_LL | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=2;<br>GAIN=4 | POS TARG -1.23270,-1.30535 | Sequence 1-5 Non-Int in V2-TWHYA (02) | 220 Secs (220 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | *[1]* |
| 4 | TWHYA_BAR10_LR | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=2;<br>GAIN=4 | POS TARG 1.33805,-1.30016 | Sequence 1-5 Non-Int in V2-TWHYA (02) | 220 Secs (220 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | *[1]* |
| 5 | TWHYA_BAR5_CENTER | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR5 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=4;<br>GAIN=4 | | Sequence 1-5 Non-Int in V2-TWHYA (02) | 440 Secs (440 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]* | *[1]* |

Orbit Structure



## Visit

**Proposal 16785, V3-PSF-TWHYA (03), completed** Thu Sep 07 23:00:24 GMT 2023

**Diagnostic Status: No Diagnostics**

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; GUID TOL 0.005"; GYRO MODE 3GOBAD; SCHED 100%; AFTER 02 BY .5 Orbits TO 1.5 Orbits

*Comments: PSF (HD 85512). PSF calibration target for TW Hya. V = 7.636. B - V = +1.15. Spex. K6Vk*

*This is the PSF star calibrator for the flanking visits (1-4). We levy no orientation constraints on this visit (3). However, we choose this target since it has been used in the past for TW Hya. So as Visits 2 and 3 must be scheduled in sequential contiguous orbits, if scheduled at nominal roll (as we expect also Visit 2 will be) then we expect absolute orientations of Visits 2 and 3 to be very similar (within a few degrees). This is important so we maintain similar Sun and Beta angles for the science target and its PSF calibrator,*

*Relative Timing: This visit (3) should immediately follow visit 2 and immediately precede visit 4. I.e., they should be executed sequentially in "back-to-back" orbits.*

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (2) | PSF-REF-HD85512 | RA: 09 51 7.7094 (147.7821225d) | Proper Motion RA: 461 mas/yr | V=7.651 | Reference Frame: ICRS |
| | | Dec: -43 30 17.34 (-43.50482d) | Proper Motion Dec: -472.0 mas/yr | | |
| | | Equinox: J2000 | Epoch of Position: 2015.5 | | |

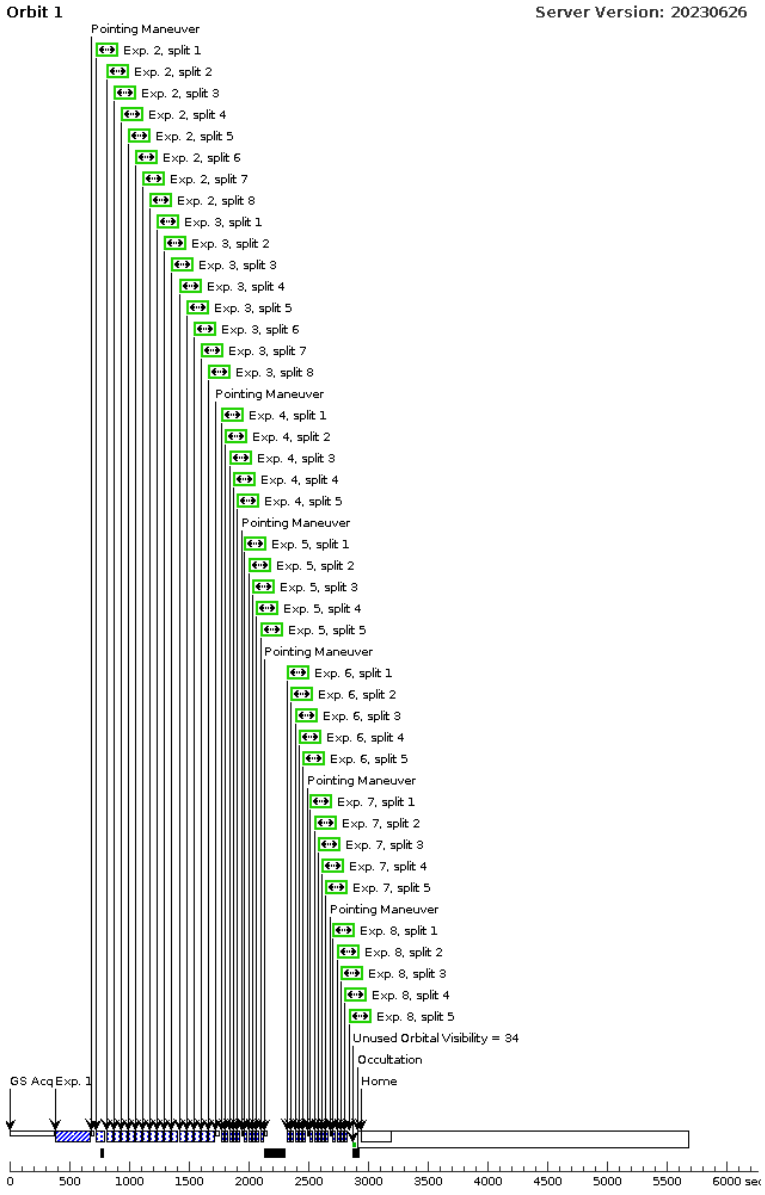
*Comments: possible spoiler star from original 2000 program is now at ~5.73" in 2021.*
*Category=STAR*
*Description=[M V-IV]*
*Extended=NO*

**Exposures**

| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | PSF-TWHYA_ACQ (STIS.ta.1447816) | (2) PSF-REF-HD85512 | STIS/CCD, ACQ, F25ND3 | MIRROR | | GS ACQ SCENARIO BASE1B3 | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | .7 Secs (0.7 Secs)<br>*[==>]* | ***[1]*** |
| | *Comments: K6V nearby star V=7.65*<br>*Exptime rounded to nearest 0.1 second, assumed to get SNR=100.* | | | | | | | | |
| 2 | PSF_TWHYA_LONG_1 | (2) PSF-REF-HD85512 | STIS/CCD, ACCUM, WEDGEA1.0 | MIRROR | SIZEAXIS2=427;<br>CR-SPLIT=8;<br>GAIN=4 | | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | 256 Secs (256 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]*<br>*[==>(Split 5)]*<br>*[==>(Split 6)]*<br>*[==>(Split 7)]*<br>*[==>(Split 8)]* | ***[1]*** |
| 3 | PSF_TWHYA_LONG_2 | (2) PSF-REF-HD85512 | STIS/CCD, ACCUM, WEDGEA1.0 | MIRROR | SIZEAXIS2=427;<br>GAIN=4;<br>CR-SPLIT=8 | | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | 256 Secs (256 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]*<br>*[==>(Split 5)]*<br>*[==>(Split 6)]*<br>*[==>(Split 7)]*<br>*[==>(Split 8)]* | ***[1]*** |
| 4 | PSF_TWHYA_BAR10_LR | (2) PSF-REF-HD85512 | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=5;<br>GAIN=4 | POS TARG 1.33805, -1.30016 | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | 56 Secs (56 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]*<br>*[==>(Split 5)]* | ***[1]*** |
| 5 | PSF_TWHYA_BAR10_LL | (2) PSF-REF-HD85512 | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=5;<br>GAIN=4 | POS TARG -1.232770,-1.30535 | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | 56 Secs (56 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]*<br>*[==>(Split 5)]* | ***[1]*** |
| 6 | PSF-TWHYA_BAR5_CENTER | (2) PSF-REF-HD85512 | STIS/CCD, ACCUM, BAR5 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=5;<br>GAIN=4 | | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | 56 Secs (56 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]*<br>*[==>(Split 5)]* | ***[1]*** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | PSF-TWHYA_BAR5_PLUSDITHER | (2) PSF-REF-HD855 12 | STIS/CCD, ACCUM, BAR5 | MIRROR | SIZEAXIS2=100; CR-SPLIT=5; GAIN=4 | POS TARG 0.0024795,0.0124497 | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | 56 Secs (56 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]*<br>*[==>(Split 5)]* | ***[1]*** |
| | 8 | PSF-TWHYA_BAR5_MINUSDITHER | (2) PSF-REF-HD855 12 | STIS/CCD, ACCUM, BAR5 | MIRROR | SIZEAXIS2=100; CR-SPLIT=5; GAIN=4 | POS TARG -0.0024795,-0.0124497 | Sequence 1-8 Non-Int in V3-PSF-TWHYA (03) | 56 Secs (56 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]*<br>*[==>(Split 5)]* | ***[1]*** |

**Orbit Structure**



## Visit

**Proposal 16785, V4-TWHYA (04), completed** Thu Sep 07 23:00:24 GMT 2023

**Diagnostic Status: Warning**

Scientific Instruments: STIS/CCD

Special Requirements: PCS MODE FINE; GUID TOL 0.005"; GYRO MODE 3GOBAD; SCHED 100%; ORIENT 15D TO 30D FROM 02; AFTER 03 BY 0.5 Orbits TO 1.5 Orbits

*Comments: Orientation: We wish to schedule this visit (4) at +30 deg from Visit 2, with the absolute orientation of Visit 2 unconstrained.*
*We allow a relative orientation tolerence from +15 deg to +30 deg to assist in guide star selection and scheduling.*
*NOTE to PC: Schedule as close to +30 deg from Visit 2 as possible.*

*Relative Timing: This visit (4) should immediately follow Visit 3. I.e., They should be executed sequentially in "back-to-back" orbits.*

## Diagnostics

(V4-TWHYA (04)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(V4-TWHYA (04)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (1) | V-TW-HYA | RA: 11 01 51.9129 (165.4663038d)<br>Dec: -34 42 17.00 (-34.70472d)<br>Equinox: J2000 | Proper Motion RA: -68.4 mas/yr<br>Proper Motion Dec: -14.02 mas/yr<br>Epoch of Position: 1999.32 | V=10.5 | Reference Frame: ICRS |

*Comments:*
*Category=STAR*
*Description=[T TAURI STAR]*
*Extended=NO*

## Exposures

| # | Label (ETC Run) | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | TWHYA_ACQ (STIS.ta.1447817) | (1) V-TW-HYA | STIS/CCD, ACQ, F28X50LP | MIRROR | | GS ACQ SCENARIO BASE1B3 | Sequence 1-5 Non-Int in V4-TWHYA (04) | .2 Secs (0.2 Secs)<br>*[==>]* | ***[1]*** |
| 2 | TWHYA_LONG_1 | (1) V-TW-HYA | STIS/CCD, ACCUM, WEDGEA1.0 | MIRROR | SIZEAXIS2=427;<br>CR-SPLIT=2;<br>GAIN=4 | | Sequence 1-5 Non-Int in V4-TWHYA (04) | 1016 Secs (1016 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | ***[1]*** |
| 3 | TWHYA_BAR10_LL | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=2;<br>GAIN=4 | POS TARG -1.23270,-1.30535 | Sequence 1-5 Non-Int in V4-TWHYA (04) | 220 Secs (220 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | ***[1]*** |
| 4 | TWHYA_BAR10_LR | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR10 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=2;<br>GAIN=4 | POS TARG 1.33805,-1.30016 | Sequence 1-5 Non-Int in V4-TWHYA (04) | 220 Secs (220 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]* | ***[1]*** |
| 5 | TWHYA_BAR5_CENTER | (1) V-TW-HYA | STIS/CCD, ACCUM, BAR5 | MIRROR | SIZEAXIS2=100;<br>CR-SPLIT=4;<br>GAIN=4 | | Sequence 1-5 Non-Int in V4-TWHYA (04) | 440 Secs (440 Secs)<br>*[==>(Split 1)]*<br>*[==>(Split 2)]*<br>*[==>(Split 3)]*<br>*[==>(Split 4)]* | ***[1]*** |

Orbit Structure