16503 - Confirming the Host Star of a Second Planet in the LTT 1445ABC System

Cycle: 28, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

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Prof. Andrew W. Howard (CoI)	California Institute of Technology	ahoward@caltech.edu
Dr. Andrew Vanderburg (CoI)	Massachusetts Institute of Technology	andrewv@mit.edu
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Alton Spencer (CoI)	Western Connecticut State University	altspen14@gmail.com

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
02	(1) BD-17-588	WFC3/UVIS	3	07-Sep-2021 15:00:29.0	yes
03	(1) BD-17-588	WFC3/UVIS	3	07-Sep-2021 15:00:46.0	yes

6 Total Orbits Used

ABSTRACT

At 6.9 pc, the triple star system LTT 1445 ABC is the closest M dwarf system known to host a transiting, terrestrial exoplanet. We have detected a second transiting planet in the system; however, the shallow transit depth, low SNR light curves, and placement of all three stars on one 21" TESS pixel have thwarted ground-based efforts to determine which of the three stars is the host of the new planet. This is necessary in order to accurately measure the mass of either planet in the system and will be important for future JWST observations of one or both of the LTT 1445 planets. We propose to obtain HST WFC3/UVIS photometric observations in spatial scan mode of 2 transits of the newly detected planet candidate to determine which of the three stars is the host star. This confirmation can only be done with HST.

OBSERVING DESCRIPTION

For our program, we will use WFC3/UVIS imaging in spatial scan mode with a photometric filter to accomplish our science goals. The need to spatially separate the three stars motivates our choice of WFC3 UVIS photometry. For this system, composed of three mid-to-late M dwarfs and two planets, photometric filters are preferred over the UVIS G280 and STIS G430L spectroscopic grisms because the stars have minimal flux at short wavelengths. Unlike STIS and WFC3 IR, the WFC3 UVIS CCD is incredibly stable and does not experience the same persistence (ramp) effects that the other detectors do, as shown by Wakeford et al., 2020; this has allowed us to include the first orbit in our analysis, where it would normally have to be removed, e.g.,Deming et al., 2013 and Sing et al., 2016.

In total we request 6 HST orbits to determine which of the three stars is being transited by the 3-day period planet. Because the shape of the transit is uncertain, we will observe the system for two transits (3 orbits per transit), where one orbit will capture the transit and an orbit on either side of the transit will establish an-out-of-transit baseline.

For each observation we will use WFC3 in spatial scan mode to spread the light over a row of pixels on the detector and increase the SNR per exposure, as well as the observational efficiency. Although spatial scanning of WFC3/UVIS photometry is not as widely used as other modes for time-series observations, its use and expected performance are detailed in the WFC3 instrument handbook and at least two instrument science reports (ISR WFC3 2017-21 and WFC3 2012-08). Spatial scanning of WFC3/UVIS photometry has been used in at least four previous programs aimed at high-precision observations of exoplanet systems: 14621/15119 (PI Wang, Target=Beta Pic, Vmag=3.86, scan length=55 arcsec), 15129 (PI Burke, Target=Kepler-62, Vmag=13.8, scan length=6 arcsec), and 15473 (PI Fraine, Target=WASP-43, Vmag=12.4, scan length=19 arcsec). These

programs highlight the versatility and flexibility of the WFC3/UVIS photometric scanning mode that in practice allows for semi-infinite combinations of filters, scan rates, scan lengths, and subarray sizes to maximize the achievable SNR per exposure. If selected, we will work closely with the staff at STScI to further optimize our scanning parameters and subarray choice to ensure the highest possible per point precision on our transit light curve and most efficient observing strategy.

Using the WFC3 UVIS Imaging Scan Mode ETC, we calculate the exposure time, number of exposures per orbit, scan rate and length, and SNR per exposure. For each calculation we make a conservative estimate on the precision per transit to ensure that our measurements will meet our observational goals. Scan lengths on previous WFC3/UVIS spatial scan programs have ranged from 6 arcsec (Kepler-62) to 55 arcsec (Beta Pic). A 20 arcsec scan length should fit nicely into a 1024x1024 subarray, which would accommodate all three stars. In limiting the scan rate to less than 1 arcsec/s (per WFC3 handbook guidance), we cannot use the F350LP filter used in programs 15129 (Burke) and 15473 (Fraine) due to exceeding the maximum of 48000 electrons per pixel. Instead we opt for the F814W filter, which still offers exceptional throughput and wavelength coverage while avoiding the Halpha line that is sensitive to stellar flares, a consideration for this star system. The PSF width at the central wavelength of the F814W filter (802.4 nm) is approximately 1.844 pix or 0.074 arcsec. This will allow us to separate the traces/scans of the B and C components, currently separated by roughly 1 arcsec. In optimizing our observations for the F814W filter, we calculate that a scan rate of 0.85 arcsec/s keeps us just below the max electrons per pixel, resulting in roughly 23.5 second exposures with SNR~8000 (125 ppm precision). Thus, each 23.5 s exposure will constitute a 10-sigma detection of the 1200ppm deep transit. Our cadence will provide excellent coverage of the transit events, and with a 10-sigma precision per point we will accurately measure the transit parameters, notably the impact parameter.

We note that spatial scanning on Hubble is also often used for astrometric measurements, emphasizing further that our photometric spatial scanning approach is the correct one to disentangle this system and determine the true properties of this exciting new planet.

The observations proposed here make use of undithered imaging strategies that have become standard for time-series observations of exoplanets with Hubble. Dithering would in fact hinder our ability to achieve our required precision for this program and is not advisable when using the spatial scanning modes of WFC3. In each visit, we are targeting three spatially resolved point sources and making relative, not absolute, photometric measurements of their brightnesses. Robust strategies to deal with hot pixels and other detector artifacts that do not require dithering have been developed over the last decade of exoplanet observations with Hubble. Our proposed study will serve as an invaluable training set for the development of data reduction and interpretation techniques for WFC3 UVIS exoplanet observations, which
will always offer the highest achievable precision at wavelengths inaccessible to JWST.

A wide variety of analysis pipelines for Hubble WFC3 spatially-scanned data exist and can be easily adapted to tackle the proposed observations. We note that special care will need to be taken in selecting extraction apertures for the B and C stellar components of this system given their spatial proximity.

Visit

Proposal 16503, X-scan - 1 (02), scheduling Tue Sep 07 19:00:48 GMT 2021

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: SCHED 100%; ORIENT 65D TO 115 D; ORIENT 245D TO 295 D; BETWEEN 01-JUN-2021:00:00:00 AND 10-SEP-2021:00:00:00; BETWEEN 11-SEP-2021:00:00:00 AND 01-JAN-2022:00:00:00; Period 3.1239030 D AND ZERO-PHASE HJD2458412.58095

Comments: Scheduling requirements: Require 3 non-interrupt Hubble orbits to cover the transit event

In order to achieve our science goals we must have good temporal coverage of the transit event. Standard UVIS subarray options are not compatible with our science goals as they all require buffer dumps before any given observing window closes (assuming scan length of 20", scan rate = 0.67 "/sec, and exposure time of 30 seconds). We have determined that a subarray 30" (750 pixels) in length (scan direction) and 15" (376 pixels) wide (across the triple star system) is best suited to achieving our science goals.

First exposure is an imaging snapshot of the LTT1445 system in the same location as the scans that follow

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-We have adjusted the scan POSTARG to hopefully better center the scan in the subarray. Note that we have specified the target coordinates that represent the center of the LTT1445 A and BC stellar components, so the system should be well centered perpendicular to the scan.

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-We have included between constraints to avoid instances of planet b and planet c transiting within the same window. For Cycle 28 the following should be avoided:
BJD 2458996.75107 MJD_UTC 58996.2546 Cyc 187 2020-05-27 06:06:38 UT dt -1.5 hr
BJD 2459034.23787 MJD_UTC 59033.7392 Cyc 199 2020-07-03 17:44:27 UT dt -2.1 hr
BJD 2459071.72467 MJD_UTC 59071.2230 Cyc 211 2020-08-10 05:21:05 UT dt -2.7 hr
BJD 2459109.21147 MJD_UTC 59108.7071 Cyc 223 2020-09-16 16:58:14 UT dt -3.3 hr
BJD 2459355.99957 MJD_UTC 59355.5033 Cyc 302 2021-05-21 12:04:48 UT dt 3.6 hr
BJD 2459393.48637 MJD_UTC 59392.9882 Cyc 314 2021-06-27 23:42:56 UT dt 3.0 hr
BJD 2459430.97317 MJD_UTC 59430.4720 Cyc 326 2021-08-04 11:19:40 UT dt 2.4 hr
BJD 2459468.45997 MJD_UTC 59467.9560 Cyc 338 2021-09-10 22:56:36 UT dt 1.8 hr
BJD 2459505.94677 MJD_UTC 59505.4412 Cyc 350 2021-10-18 10:35:23 UT dt 1.2 hr
BJD 2459543.43357 MJD_UTC 59542.9284 Cyc 362 2021-11-24 22:16:56 UT dt 0.6 hr
BJD 2459580.92037 MJD_UTC 59580.4174 Cyc 374 2022-01-01 10:01:06 UT dt 0.0 hr

Diagnostics

(Snapshot - Orbit 1 (02.001)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

(Snapshot - Orbit 1 (02.002)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

(Scan Exposures - Orbit 1 (02.003)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

(Scan Exposures - Orbit 2 (02.004)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

(Scan Exposures - Orbit 3 (02.005)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	BD-17-588 Alt Name1: LTT1445ABC	RA: 03 01 51.2140 (45.4633917d) Dec: -16 35 33.45 (-16.59262d) Equinox: J2000	Proper Motion RA: -0.36997184335074684 arcsec/yr Proper Motion Dec: -0.267931311928784 arcsec/yr Parallax: 0.1456922" Epoch of Position: 2000.0 Radial Velocity: -5.5 km/sec	V=11.22+/-0.03	Reference Frame: ICRS

Comments: The original target coordinates generated by the targetselector and retrieved from the SIMBAD database were RA: 03 01 51.4000 and DEC: -16 35 36.00. We have adjusted the target coordinate to refer to the center of the LTT1445 system J2000 RA: 03 01 51.214 and Dec: -16 35 33.45
Category=STAR
Description=[M V-IV]
Extended=NO

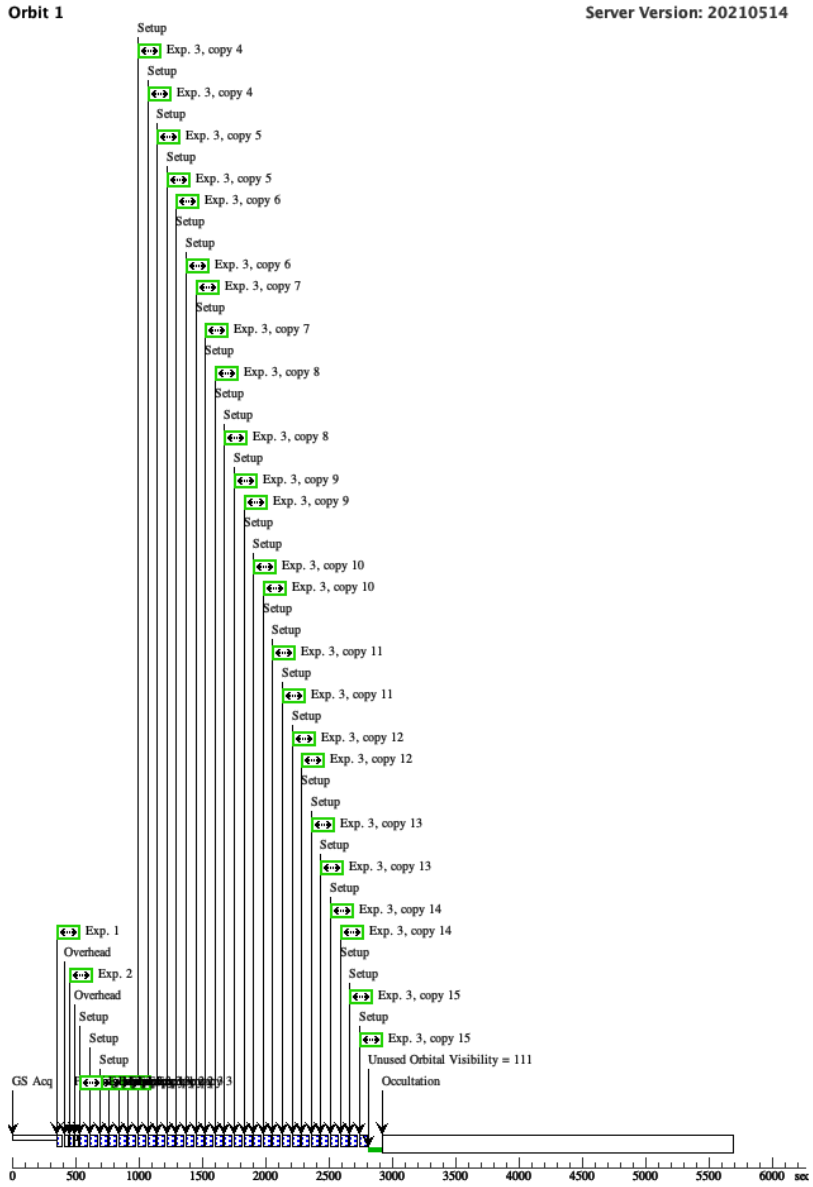
Exposures

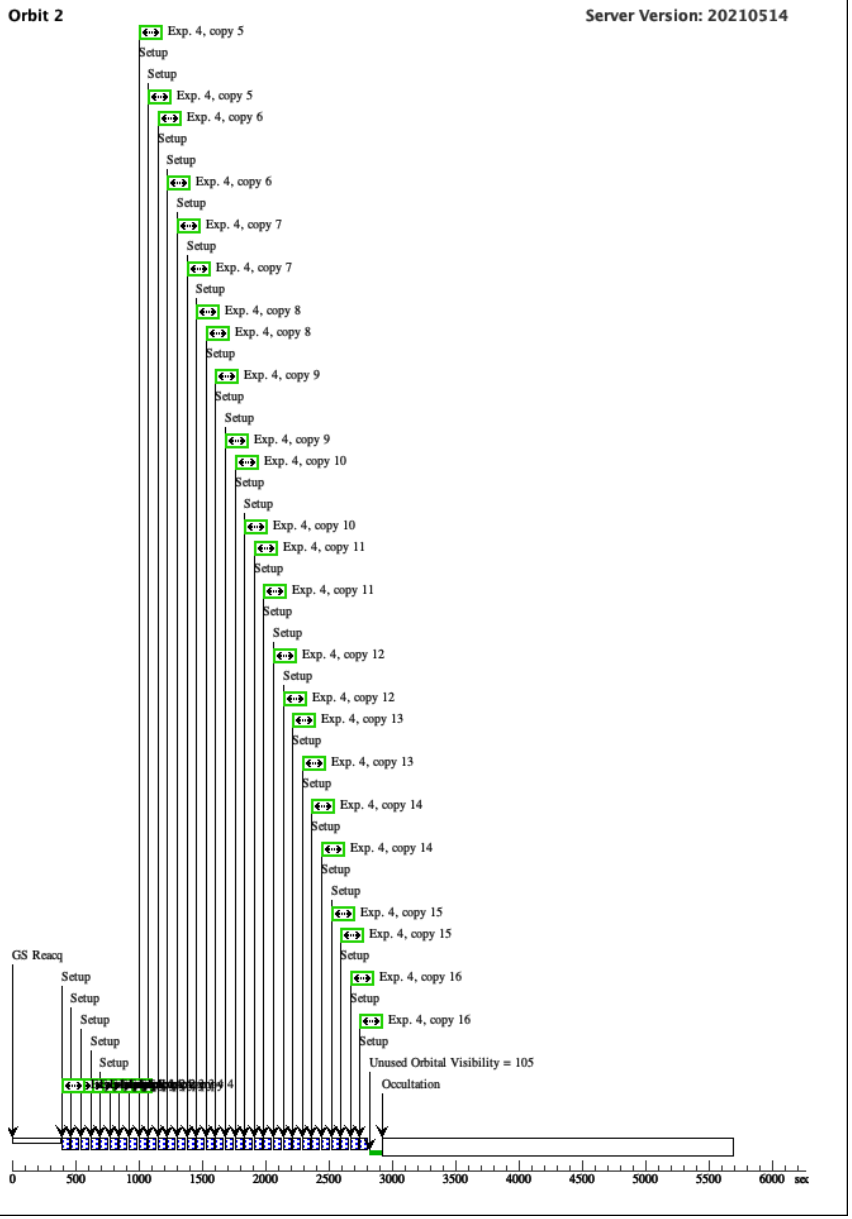
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Snapshot - Orbit 1 (WFC3UVIS.im.1492191)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W		POS TARG 0,0	Sequence 1-3 Non-Int in X-scan - 1 (02)	10 Secs (10 Secs) *[==>]*	***[1]***
2	Snapshot - Orbit 1 (WFC3UVIS.im.1492191)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W		POS TARG 0,0; PHASE 0.9699894651 TO 0.97443547027	Sequence 1-3 Non-Int in X-scan - 1 (02)	0.5 Secs (0.5 Secs) *[==>]*	***[1]***
3	Scan Exposures - Orbit 1 (WFC3UVIS.si.1492391)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W		POS TARG -7.35,0; SPATIAL SCAN 0.67,3.7702 Degrees,Round trip	Sequence 1-3 Non-Int in X-scan - 1 (02)	22.0 Secs X 15 (660 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]* *[==>(Copy 9, Forward)]* *[==>(Copy 9, Reverse)]* *[==>(Copy 10, Forward)]* *[==>(Copy 10, Reverse)]* *[==>(Copy 11, Forward)]* *[==>(Copy 11, Reverse)]* *[==>(Copy 12, Forward)]* *[==>(Copy 12, Reverse)]* *[==>(Copy 13, Forward)]* *[==>(Copy 13, Reverse)]* *[==>(Copy 14, Forward)]* *[==>(Copy 14, Reverse)]* *[==>(Copy 15, Forward)]* *[==>(Copy 15, Reverse)]*	***[1]***

	4	Scan Exposures - Orbit 2 (WFC3UVIS.si.1492391)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W	POS TARG -7.35,0.0; SPATIAL SCAN 0.67,3.7702 Degrees,Round trip	Sequence 4-4 Non-Int in X-scan - 1 (02)	22. Secs X 16 (704 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]* *[==>(Copy 9, Forward)]* *[==>(Copy 9, Reverse)]* *[==>(Copy 10, Forward)]* *[==>(Copy 10, Reverse)]* *[==>(Copy 11, Forward)]* *[==>(Copy 11, Reverse)]* *[==>(Copy 12, Forward)]* *[==>(Copy 12, Reverse)]* *[==>(Copy 13, Forward)]* *[==>(Copy 13, Reverse)]* *[==>(Copy 14, Forward)]* *[==>(Copy 14, Reverse)]* *[==>(Copy 15, Forward)]* *[==>(Copy 15, Reverse)]* *[==>(Copy 16, Forward)]* *[==>(Copy 16, Reverse)]*	***[2]***

	5	Scan Exposures - Orbit 3 (WFC3UVIS.si.1492391)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W	POS TARG -7.35,0.0; SPATIAL SCAN 0.67,3.7702 Degrees,Round trip	Sequence 5-5 Non-Int in X-scan - 1 (02)	22.0 Secs X 16 (704 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]* *[==>(Copy 9, Forward)]* *[==>(Copy 9, Reverse)]* *[==>(Copy 10, Forward)]* *[==>(Copy 10, Reverse)]* *[==>(Copy 11, Forward)]* *[==>(Copy 11, Reverse)]* *[==>(Copy 12, Forward)]* *[==>(Copy 12, Reverse)]* *[==>(Copy 13, Forward)]* *[==>(Copy 13, Reverse)]* *[==>(Copy 14, Forward)]* *[==>(Copy 14, Reverse)]* *[==>(Copy 15, Forward)]* *[==>(Copy 15, Reverse)]* *[==>(Copy 16, Forward)]* *[==>(Copy 16, Reverse)]*	***[3]***

Orbit Structure




Orbit 2
Server Version: 20210514
Exp. 4, copy 5
Setup
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Exp. 4, copy 7
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Exp. 4, copy 16
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Exp. 4, copy 16
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Unused Orbital Visibility = 105
Occultation
GS Reacq
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4500
5000
5500
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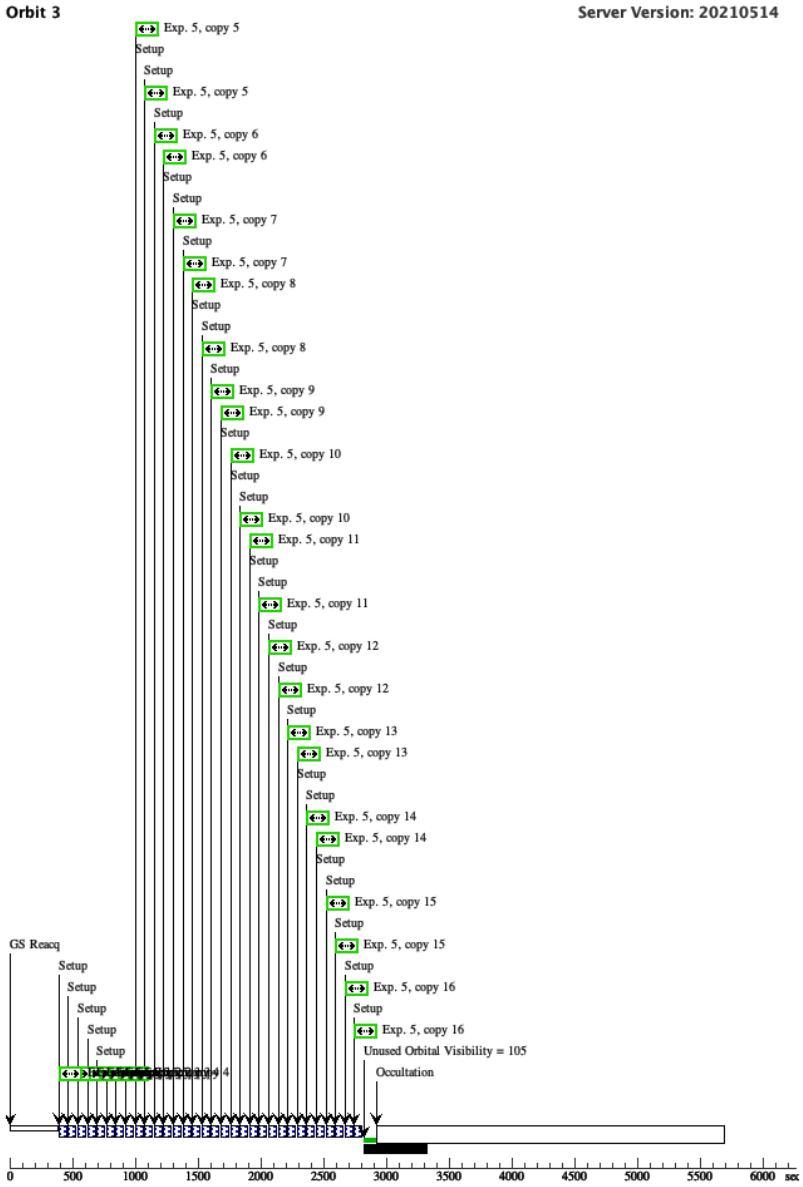
Orbit 3
Server Version: 20210514
Exp. 5, copy 5
Setup
Exp. 5, copy 6
Exp. 5, copy 7
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Exp. 5, copy 9
Exp. 5, copy 10
Exp. 5, copy 11
Exp. 5, copy 12
Exp. 5, copy 13
Exp. 5, copy 14
Exp. 5, copy 15
Exp. 5, copy 16
GS Reacq
Unused Orbital Visibility = 105
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec

Visit

Proposal 16503, X-scan - 2 (03), implementation Tue Sep 07 19:00:48 GMT 2021

Diagnostic Status: Warning

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(Scan Exposures - Orbit 3 (03.005)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	BD-17-588 Alt Name1: LTT1445ABC	RA: 03 01 51.2140 (45.4633917d) Dec: -16 35 33.45 (-16.59262d) Equinox: J2000	Proper Motion RA: -0.36997184335074684 arcsec/yr Proper Motion Dec: -0.267931311928784 arcsec/yr Parallax: 0.1456922" Epoch of Position: 2000.0 Radial Velocity: -5.5 km/sec	V=11.22+/-0.03	Reference Frame: ICRS

Comments: The original target coordinates generated by the targetselector and retrieved from the SIMBAD database were RA: 03 01 51.4000 and DEC: -16 35 36.00. We have adjusted the target coordinate to refer to the center of the LTT1445 system J2000 RA: 03 01 51.214 and Dec: -16 35 33.45
Category=STAR
Description=[M V-IV]
Extended=NO

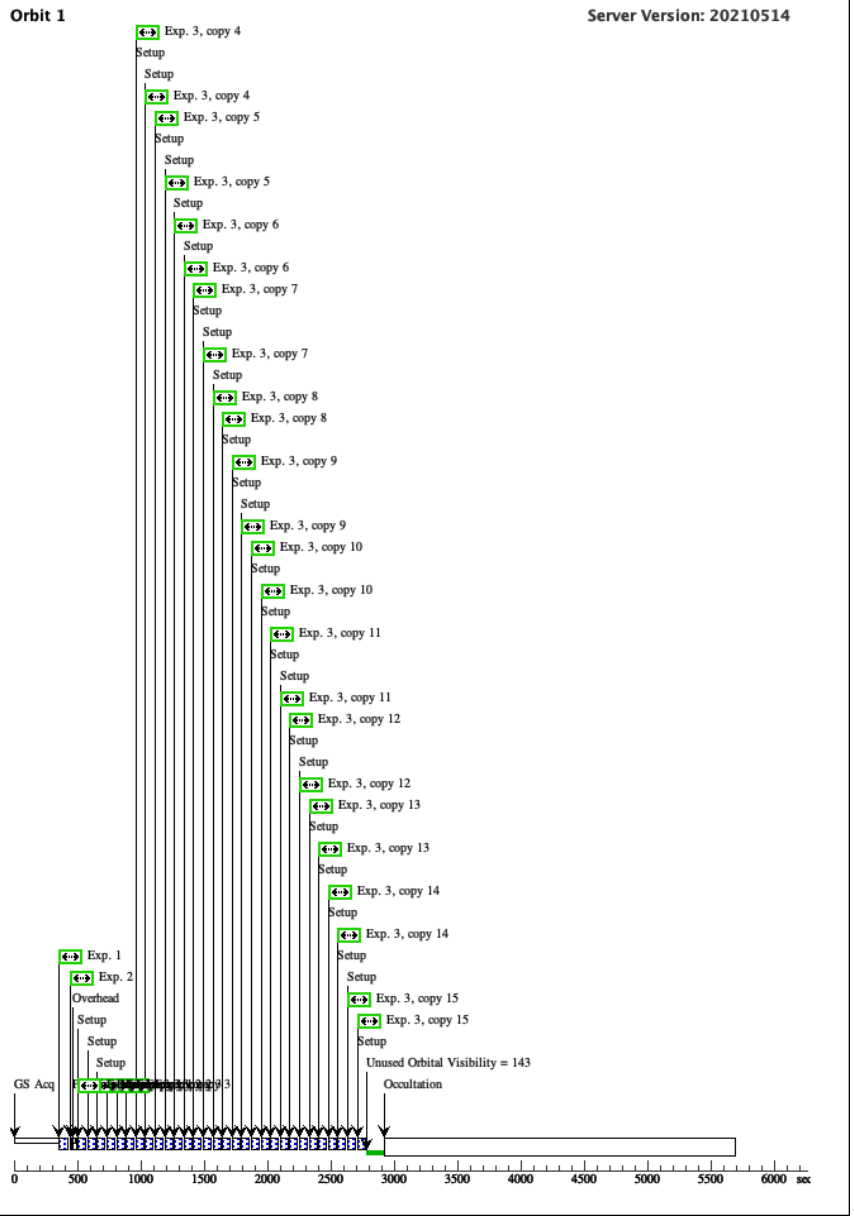
Exposures

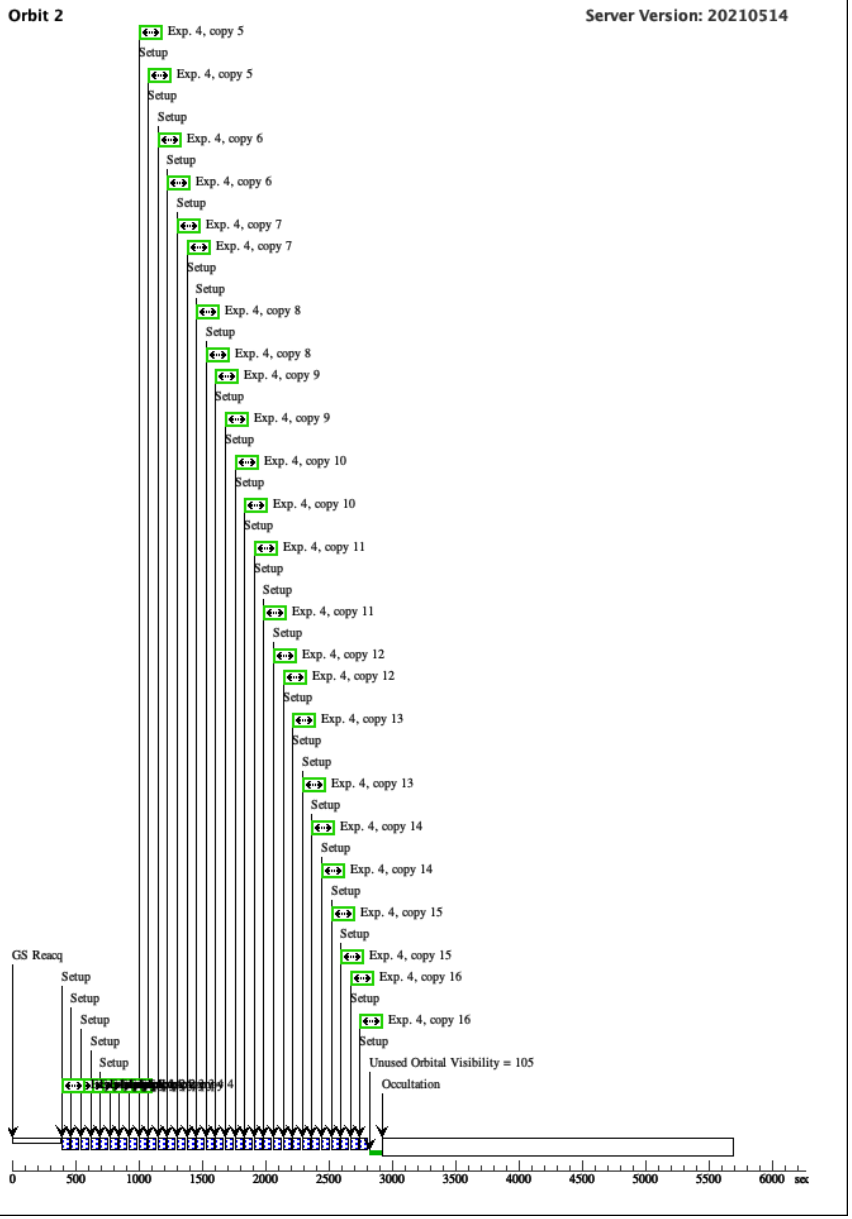
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Snapshot - Orbit 1 (WFC3UVIS.im.1492191)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W		POS TARG 0,0; PHASE 0.96665496122 TO 0.97443547027	Sequence 1-3 Non-Int in X-scan - 2 (03)	0.5 Secs (0.5 Secs) *[==>]*	*[1]*
2	Snapshot - Orbit 1 (WFC3UVIS.im.1492191)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W		POS TARG 0,0	Sequence 1-3 Non-Int in X-scan - 2 (03)	10 Secs (10 Secs) *[==>]*	*[1]*
3	Scan Exposures - Orbit 1 (WFC3UVIS.si.1492391)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W		POS TARG -7.35,0; SPATIAL SCAN 0.67,3.7702 Degrees,Round trip	Sequence 1-3 Non-Int in X-scan - 2 (03)	22.0 Secs X 15 (660 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]* *[==>(Copy 9, Forward)]* *[==>(Copy 9, Reverse)]* *[==>(Copy 10, Forward)]* *[==>(Copy 10, Reverse)]* *[==>(Copy 11, Forward)]* *[==>(Copy 11, Reverse)]* *[==>(Copy 12, Forward)]* *[==>(Copy 12, Reverse)]* *[==>(Copy 13, Forward)]* *[==>(Copy 13, Reverse)]* *[==>(Copy 14, Forward)]* *[==>(Copy 14, Reverse)]* *[==>(Copy 15, Forward)]* *[==>(Copy 15, Reverse)]*	*[1]*

	4	Scan Exposures - Orbit 2 (WFC3UVIS.si.1492391)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W	POS TARG -7.35,0.0; SPATIAL SCAN 0.67,3.7702 Degrees,Round trip	Sequence 4-4 Non-Int in X-scan - 2 (03)	22. Secs X 16 (704 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]* *[==>(Copy 9, Forward)]* *[==>(Copy 9, Reverse)]* *[==>(Copy 10, Forward)]* *[==>(Copy 10, Reverse)]* *[==>(Copy 11, Forward)]* *[==>(Copy 11, Reverse)]* *[==>(Copy 12, Forward)]* *[==>(Copy 12, Reverse)]* *[==>(Copy 13, Forward)]* *[==>(Copy 13, Reverse)]* *[==>(Copy 14, Forward)]* *[==>(Copy 14, Reverse)]* *[==>(Copy 15, Forward)]* *[==>(Copy 15, Reverse)]* *[==>(Copy 16, Forward)]* *[==>(Copy 16, Reverse)]*	***[2]***

	5	Scan Exposures - Orbit 3 (WFC3UVIS.si.1492391)	(1) BD-17-588	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W	POS TARG -7.35,0.0; SPATIAL SCAN 0.67,3.7702 Degrees,Round trip	Sequence 5-5 Non-Int in X-scan - 2 (03)	22.0 Secs X 16 (704 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]* *[==>(Copy 9, Forward)]* *[==>(Copy 9, Reverse)]* *[==>(Copy 10, Forward)]* *[==>(Copy 10, Reverse)]* *[==>(Copy 11, Forward)]* *[==>(Copy 11, Reverse)]* *[==>(Copy 12, Forward)]* *[==>(Copy 12, Reverse)]* *[==>(Copy 13, Forward)]* *[==>(Copy 13, Reverse)]* *[==>(Copy 14, Forward)]* *[==>(Copy 14, Reverse)]* *[==>(Copy 15, Forward)]* *[==>(Copy 15, Reverse)]* *[==>(Copy 16, Forward)]* *[==>(Copy 16, Reverse)]*	***[3]***

Orbit Structure

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Exp. 4, copy 7
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Setup
Exp. 4, copy 8
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Exp. 4, copy 8
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Unused Orbital Visibility = 105
Occultation
GS Reacq
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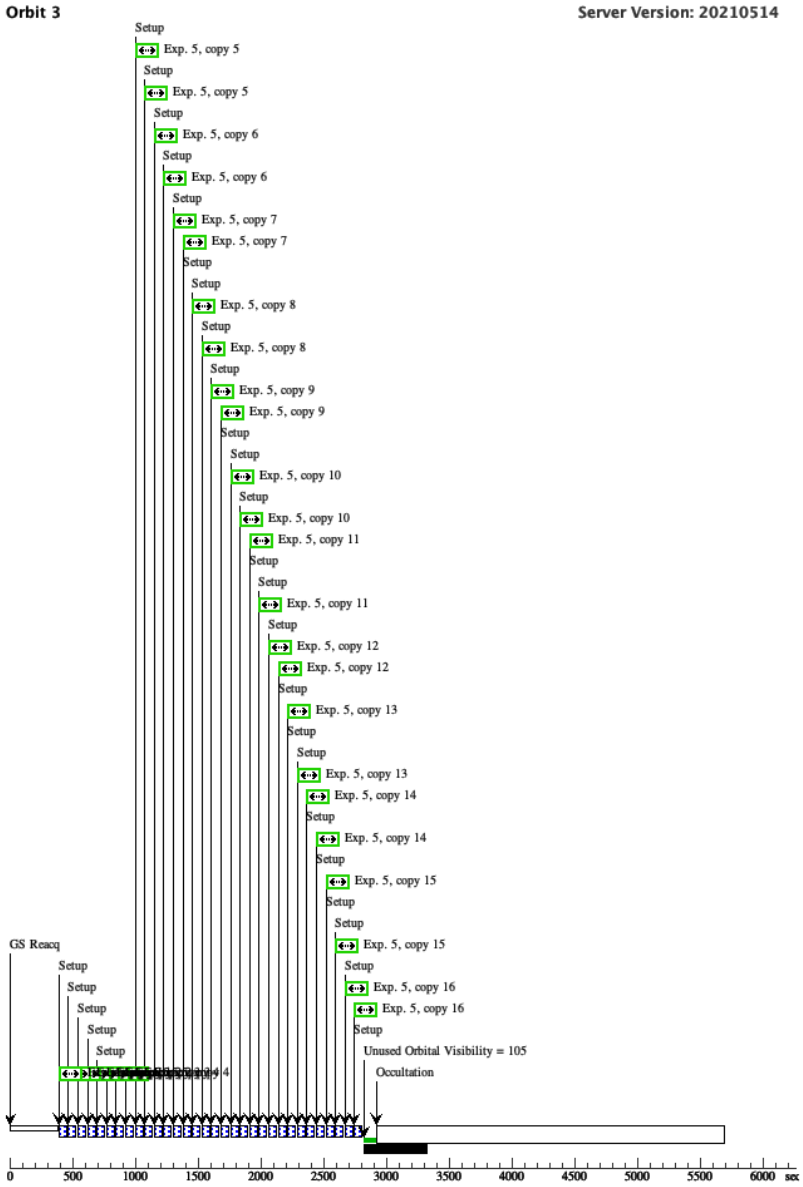
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Server Version: 20210514
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Exp. 5, copy 11
Exp. 5, copy 12
Exp. 5, copy 13
Exp. 5, copy 14
Exp. 5, copy 15
Exp. 5, copy 16
GS Reacq
Unused Orbital Visibility = 105
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec