



# 17745 - It Takes Two Planets to Tango: Constraining the Orbit of a Planetary-Mass Binary

Cycle: 32, Proposal Category: GO  
(Availability Mode: SUPPORTED)

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Dr. Christopher Theissen (PI) (Contact)</b>	<b>University of California - San Diego</b>
Dr. Luigi R. Bedin (CoI) (ESA Member)	INAF - Osservatorio Astronomico di Padova
Prof. Adam J. Burgasser (CoI)	University of California - San Diego
Dr. Daniella Carolina Bardalez Gagliuffi (CoI)	Amherst College
Dr. Clemence Fontanive (CoI) (CSA Member)	Universite de Montreal
Dr. Chih-Chun Hsu (CoI)	Northwestern University
Dr. Johanna Vos (CoI) (ESA Member)	University of Dublin, Trinity College

## 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	(1) 2MASS-J13550323-8258375	WFC3/UVIS	1	21-Aug-2024 12:00:18.0	yes
02	(1) 2MASS-J13550323-8258375	WFC3/UVIS	1	21-Aug-2024 12:00:19.0	yes
03	(1) 2MASS-J13550323-8258375	WFC3/UVIS	1	21-Aug-2024 12:00:20.0	yes
04	(1) 2MASS-J13550323-8258375	WFC3/UVIS	1	21-Aug-2024 12:00:20.0	yes
05	(1) 2MASS-J13550323-8258375	WFC3/UVIS	1	21-Aug-2024 12:00:21.0	yes
06	(1) 2MASS-J13550323-8258375	WFC3/UVIS	1	21-Aug-2024 12:00:22.0	yes

6 Total Orbits Used

## **ABSTRACT**

We aim to measure the orbit of the planetary-mass ( $M < 13 M_{\text{Jup}}$ ) binary WISE J135501.90-825838.9, the second-lowest mass (unresolved) binary currently known. This binary was first identified as a "spectral binary," a composite object of two unresolved near-infrared spectra which have the features of two ultracool ( $T < 1300$  K) objects combined into one spectrum. A preliminary RV and parallax solution place WISE 1355-8258 within the AB Doarbus kinematic association (150-200 Myr). The WISE parallax + proper motion solution also shows a periodic astrometric signal in the residuals, which is likely due to the orbital motion of the binary. However, higher precision astrometry is needed to constrain the orbital parameters, which has an estimated period of  $P \sim 1116$  days. Using HST/WFC3-UVIS we will obtain a precise astrometric solution for the parallax and proper motion, and constrain the orbital solution in the periodic motion of the astrometric residuals using 10 orbits over the next 2 cycles (6+4 orbits). These measurements will provide the first ever direct mass measurement of a planetary-mass binary. This system will be a touchstone benchmark system for models of planet formation and evolution.

## **OBSERVING DESCRIPTION**

Each orbit is spaced at least 2 months apart and is set to cover the longest time baseline possible within Cycle 32 while also offering higher coverage during the estimated maximum orbital separation of the two binary components. We are unable to cover the entire estimated orbital period of 1116 days, but we are able to cover approximately a third of the orbit which will allow us to put preliminary constraints on the orbital motion of the binary. We have 4 additional epochs in Cycle 33, which will allow us to constrain the orbital parameters to better than 1%.

We have grouped epochs into 3 groups of 2 orbits, where each group of 2 orbits is taken within 1 month of each other, and each group is separated by 3 months, maximizing the time baseline of Cycle 32 (6 orbits total in Cycle 32). We will utilize an additional 4 orbits over the maximum time baseline of Cycle 33 to sample the majority of the estimated period. This strategy will also allow us to detect shorter and longer periods of orbital movement, between  $\sim 60$ --2000 days.

The first epoch should be taken as early as possible (approximately November 28th, 2024), and the last epoch as late as possible (approximately October 31, 2025). We have created windows for each orbit that span  $\sim 20$  days, offering flexibility in scheduling while also covering the requested time baseline for each epoch (orbit) and grouping of orbits.

Each drift-scan image is taken along a principal axis of the detector. After each drift-scan image, we perform a large dither along the same axis and

Proposal 17745 (STScI Edit Number: 0, Created: Wednesday, August 21, 2024 at 11:00:22 AM Eastern Standard Time) - Overview  
direction as the previous image before the next drift-scan image is taken along another principal axis. This effectively makes a box pattern which will help us reduce systematics.

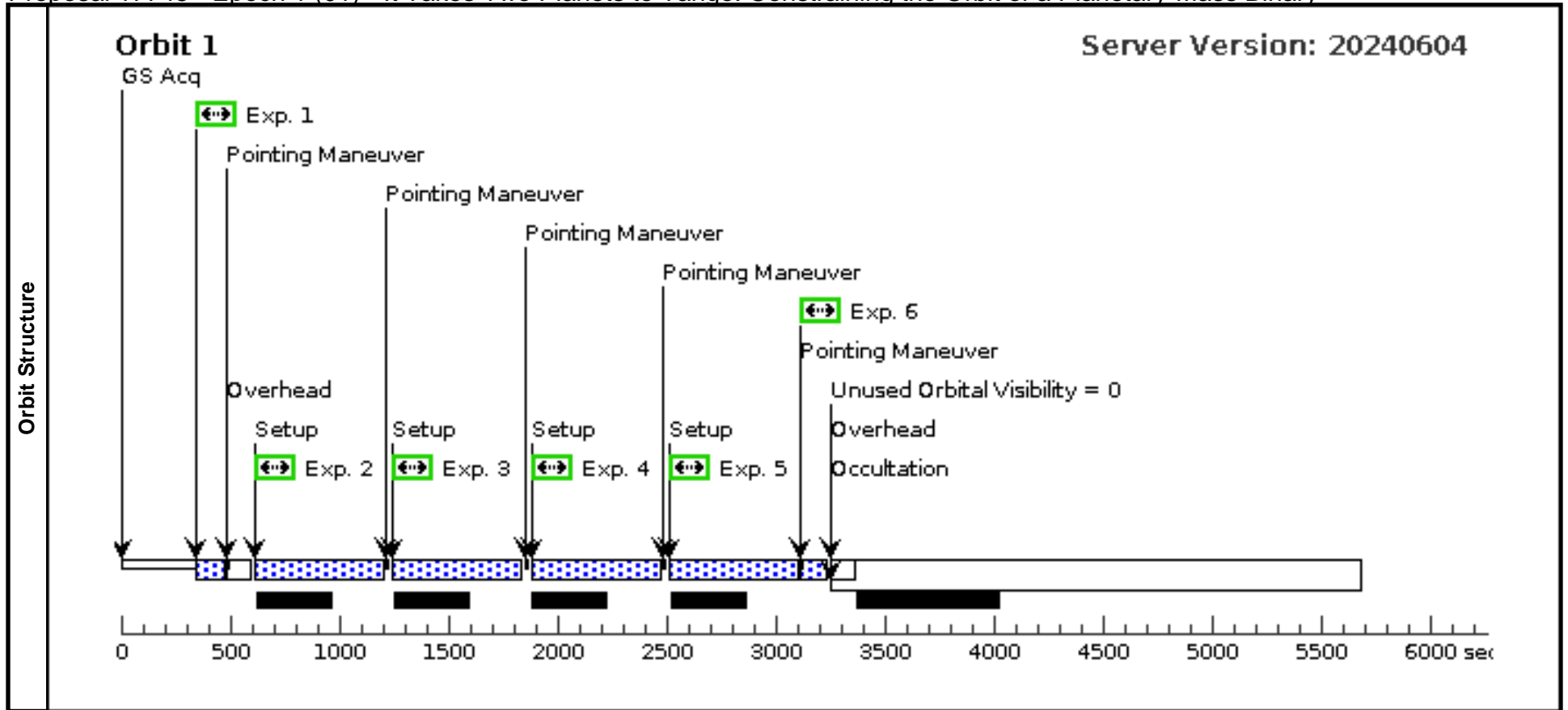
Each epoch contains two images in point source imaging mode, and four in spatial-scanning mode with WFC3/UVIS.

In addition to the images taken in spatial scan mode using F775W which will be used for absolute astrometry, we will take two short exposure (100s) point-source images at the beginning and at the end of the single orbit visits in F775W and F606W. These snapshots will provide information about calibrator source color, which is paramount to discriminate object type and distance of the reference sources in the field.

Proposal 17745 - Epoch 1 (01) - It Takes Two Planets to Tango: Constraining the Orbit of a Planetary-Mass Binary

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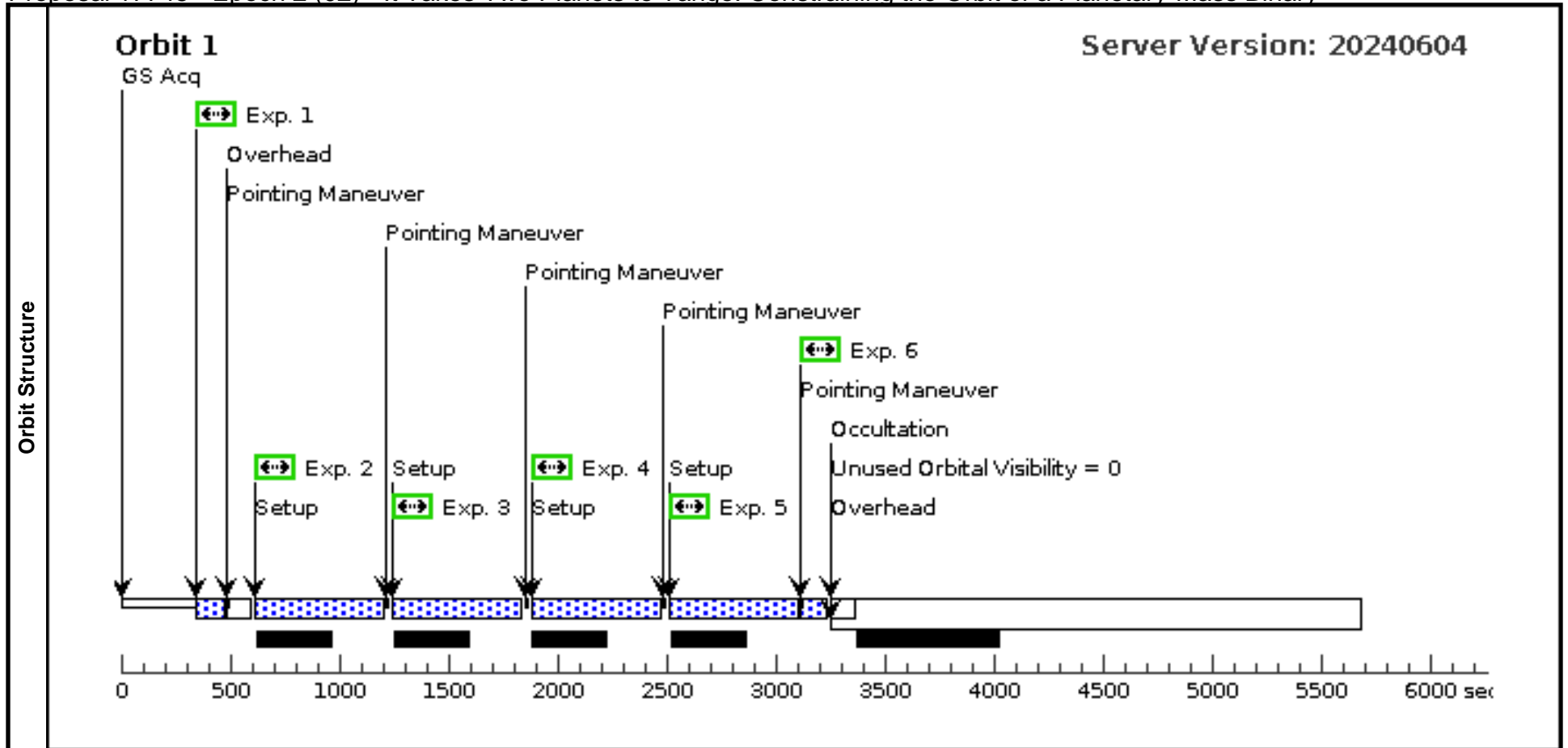
Visit	<b>Proposal 17745, Epoch 1 (01), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 28-NOV-2024:00:00:00 AND 11-DEC-2024:00:00:00									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
		(1)	2MASS-J13550323-8258375	RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000	Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010	V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137	Reference Frame: ICRS			
	<i>Comments:</i> Category=STAR Description=[BROWN DWARF, EXTRA-SOLAR PLANET] Extended=NO									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	F775W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=18	POS TARG -4,-4		100 Secs (100 Secs) [==>100 Secs ]	[1]
	2	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,-4; SPATIAL SCAN 0.0 013,270.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]
	3	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,-4; SPATIAL SCAN 0.0 013,0.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]
	4	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG 4,-4; SPATIAL SCAN 0.0 013,90.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]
	5	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG 4,4; SPATIAL SCAN 0.0 013,180.0 Degrees,Forward		400 Secs (463 Secs) [==>463.0 Secs ]	[1]
	6	F606W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F606W	FLASH=18	POS TARG -4,-4		100 Secs (100 Secs) [==>100 Secs ]	[1]



Proposal 17745 - Epoch 2 (02) - It Takes Two Planets to Tango: Constraining the Orbit of a Planetary-Mass Binary

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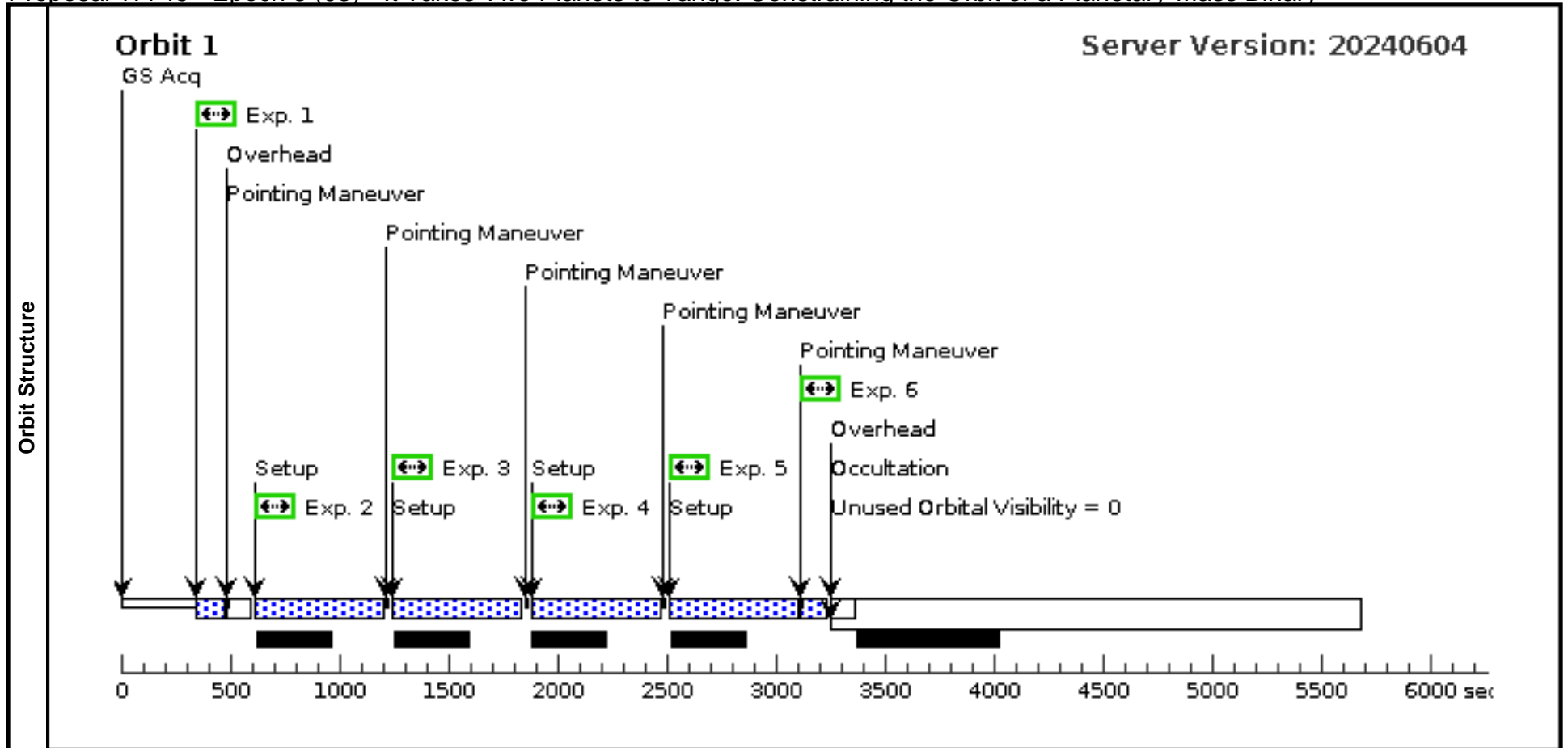
Visit	<b>Proposal 17745, Epoch 2 (02), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 11-JAN-2025:00:00:00 AND 24-JAN-2025:00:00:00									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
		(1)	2MASS-J13550323-8258375	RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000	Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010	V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137	Reference Frame: ICRS			
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	1	F775W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=18	POS TARG -4,4		100 Secs (100 Secs) [==>100.0 Secs ]	[1]
	2	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,4; SPATIAL SCAN 0.0 013,270.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]
	3	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,-4; SPATIAL SCAN 0.0 013,0.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]
	4	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG 4,-4; SPATIAL SCAN 0.0 013,90.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]
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Proposal 17745 - Epoch 3 (03) - It Takes Two Planets to Tango: Constraining the Orbit of a Planetary-Mass Binary

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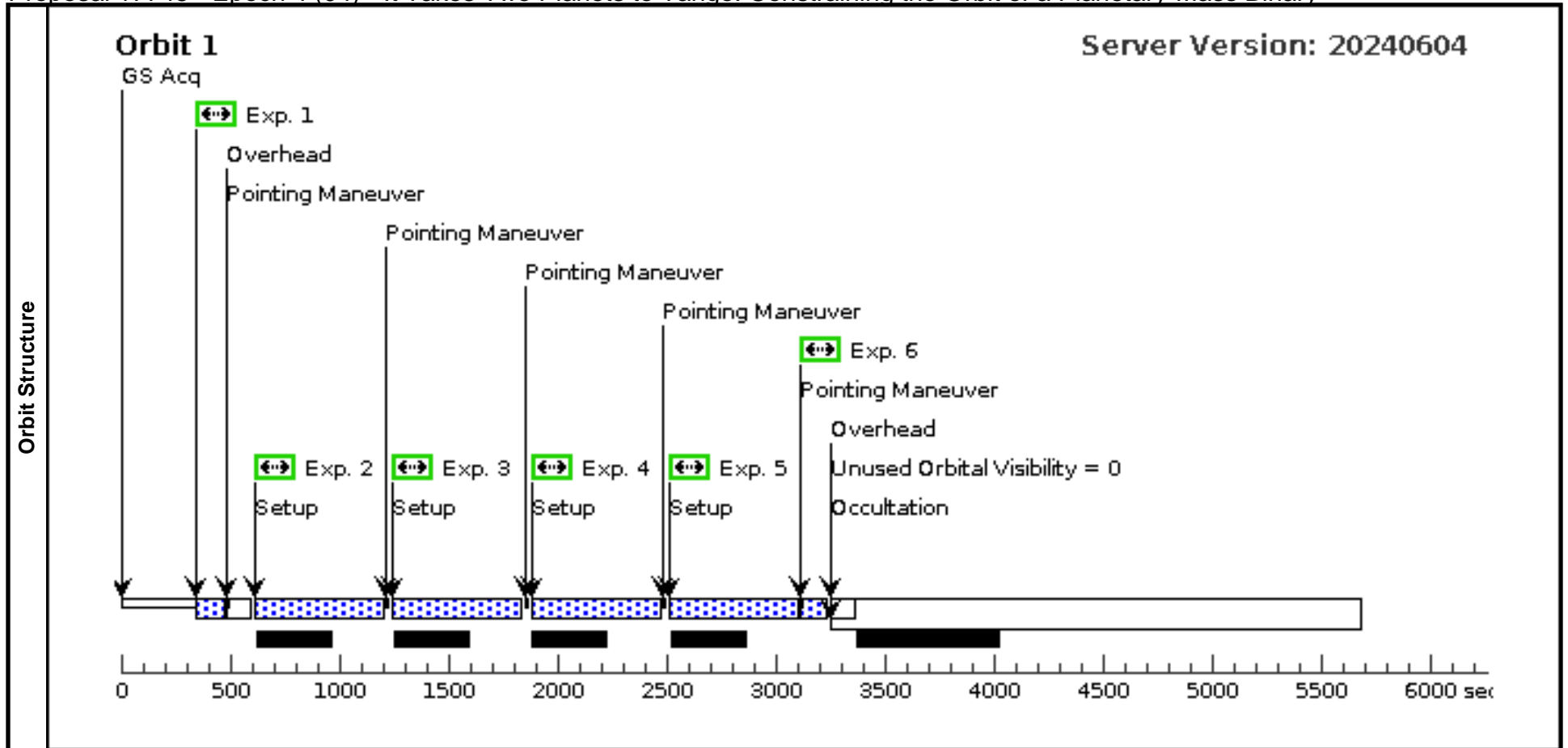
Visit	<b>Proposal 17745, Epoch 3 (03), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 11-APR-2025:00:00:00 AND 27-APR-2025:00:00:00																											
	Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>2MASS-J13550323-8258375</td> <td>RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000</td> <td>Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010</td> <td>V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137</td> <td>Reference Frame: ICRS</td> </tr> <tr> <td colspan="6"> <i>Comments:</i>                      Category=STAR                      Description=[BROWN DWARF, EXTRA-SOLAR PLANET]                      Extended=NO                 </td> </tr> </tbody> </table>										#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(1)	2MASS-J13550323-8258375	RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000	Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010	V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137	Reference Frame: ICRS	<i>Comments:</i> Category=STAR Description=[BROWN DWARF, EXTRA-SOLAR PLANET] Extended=NO				
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Proposal 17745 - Epoch 4 (04) - It Takes Two Planets to Tango: Constraining the Orbit of a Planetary-Mass Binary

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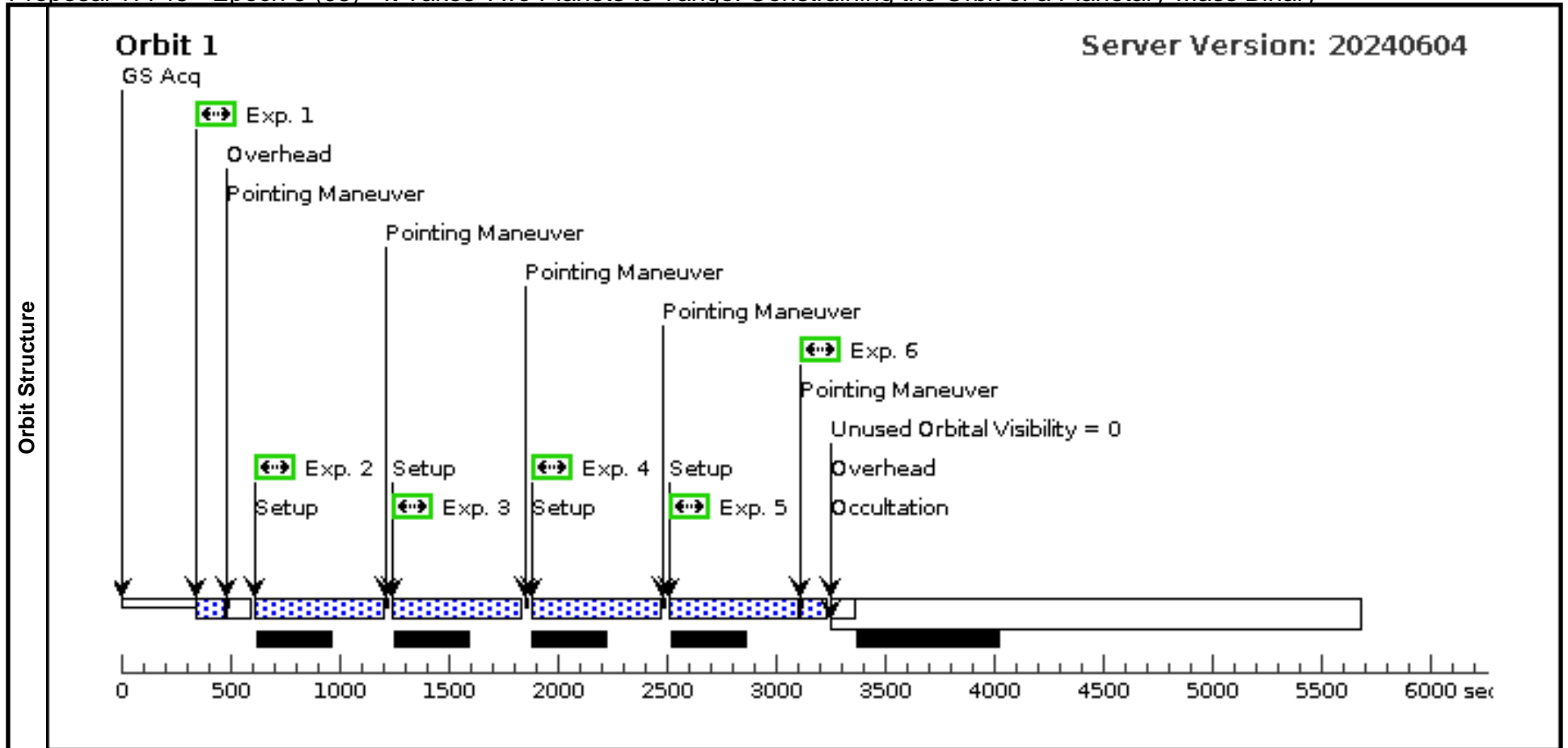
Visit	<b>Proposal 17745, Epoch 4 (04), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 29-MAY-2025:00:00:00 AND 13-JUN-2025:00:00:00																											
	Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>2MASS-J13550323-8258375</td> <td>RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000</td> <td>Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010</td> <td>V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137</td> <td>Reference Frame: ICRS</td> </tr> <tr> <td colspan="6"> <i>Comments:</i>                      Category=STAR                      Description=[BROWN DWARF, EXTRA-SOLAR PLANET]                      Extended=NO                 </td> </tr> </tbody> </table>										#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(1)	2MASS-J13550323-8258375	RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000	Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010	V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137	Reference Frame: ICRS	<i>Comments:</i> Category=STAR Description=[BROWN DWARF, EXTRA-SOLAR PLANET] Extended=NO				
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	1	F775W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=18	POS TARG -4,-4		100 Secs (100 Secs) [==>100 Secs ]	[1]																		
	2	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,-4; SPATIAL SCAN 0.0 013,270.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]																		
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	6	F606W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F606W	FLASH=18	POS TARG -4,-4		100 Secs (100 Secs) [==>100.0 Secs ]	[1]																		



Proposal 17745 - Epoch 5 (05) - It Takes Two Planets to Tango: Constraining the Orbit of a Planetary-Mass Binary

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Visit	<b>Proposal 17745, Epoch 5 (05), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 04-SEP-2025:00:00:00 AND 17-SEP-2025:00:00:00									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
		(1)	2MASS-J13550323-8258375	RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000	Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010	V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137	Reference Frame: ICRS			
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	2	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,-4; SPATIAL SCAN 0.0 013,270.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]
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	6	F606W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F606W	FLASH=18	POS TARG -4,-4		100 Secs (100 Secs) [==>100.0 Secs ]	[1]



Proposal 17745 - Epoch 6 (06) - It Takes Two Planets to Tango: Constraining the Orbit of a Planetary-Mass Binary

Wed Aug 21 16:00:23 GMT 2024

Visit	<b>Proposal 17745, Epoch 6 (06), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 22-OCT-2025:00:00:00 AND 31-OCT-2025:23:59:59																					
	Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>2MASS-J13550323-8258375</td> <td>RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000</td> <td>Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010</td> <td>V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137</td> <td>Reference Frame: ICRS</td> </tr> </tbody> </table> <p>Comments: Category=STAR Description=[BROWN DWARF, EXTRA-SOLAR PLANET] Extended=NO</p>										#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(1)	2MASS-J13550323-8258375	RA: 13 55 1.9050 (208.7579375d) Dec: -82 58 38.96 (-82.97749d) Equinox: J2000	Proper Motion RA: -248.0 mas/yr Proper Motion Dec: -161.0 mas/yr Parallax: 0.062" Epoch of Position: 2010	V=18.2+/-1 J=16.135+/-0.128; H=15.310+/-0.132; K=14.721+/-0.137
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Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit												
	1	F775W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=18	POS TARG -4,-4		100 Secs (100 Secs) [==>100 Secs ]	[1]												
	2	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,-4; SPATIAL SCAN 0.0 013,270.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]												
	3	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG -4,-4; SPATIAL SCAN 0.0 013,0.0 Degrees,Forward		400 Secs (464 Secs) [==>464.0 Secs ]	[1]												
	4	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG 4,-4; SPATIAL SCAN 0.0 013,90.0 Degrees,Forward		400 Secs (464 Secs) [==>464 Secs ]	[1]												
	5	F775W expo sure (WFC3UVI S.si.193098 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F775W	FLASH=10	POS TARG 4,4; SPATIAL SCAN 0.0 013,180.0 Degrees,Forward		400 Secs (463 Secs) [==>463.0 Secs ]	[1]												
	6	F606W Sna pshot (WFC3UVI S.im.193044 0)	(1) 2MASS-J135503 23-8258375	WFC3/UVIS, ACCUM, UVIS1	F606W	FLASH=18	POS TARG -4,-4		100 Secs (100 Secs) [==>100.0 Secs ]	[1]												

