17760 - Far Ultraviolet Doppler Tomography of a T Tauri Dipper Disk

Cycle: 32, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Eric Gaidos (PI) (Contact)	**University of Hawaii**
Prof. Kevin France (CoI)	University of Colorado at Boulder
Dr. Nicole Arulanantham (CoI)	Space Telescope Science Institute

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) V-EP-CHA	COS/FUV COS/NUV	2	13-Aug-2024 17:00:31.0	yes
02	(1) V-EP-CHA	COS/FUV COS/NUV	2	13-Aug-2024 17:00:32.0	yes
03	(1) V-EP-CHA	COS/FUV COS/NUV	2	13-Aug-2024 17:00:33.0	yes
04	(1) V-EP-CHA	COS/FUV COS/NUV	2	13-Aug-2024 17:00:34.0	yes
05	(1) V-EP-CHA	COS/FUV COS/NUV	2	13-Aug-2024 17:00:35.0	yes
06	(1) V-EP-CHA	COS/FUV COS/NUV	2	13-Aug-2024 17:00:36.0	yes

12 Total Orbits Used

ABSTRACT

To understand the formation of the thousands of planets discovered on close orbits around other stars, protoplanetary disks kindred to the ones which gave rise to these systems must be studied at <1 au scales. The inner regions of most disks cannot be spatially resolved, but they can be studied by their line-rich UV spectra, and with time-series observations that capture variability on the timescale of orbits in the inner disk. We propose multi-epoch far ultraviolet (FUV) spectroscopy of the T Tauri ``dipper'' star EP Chamaeleontis (RECX-11) with HST and COS when the Transiting Exoplanet Survey Satellite monitors the star in the optical for 27 days during Cycle 32. RECX-11 exhibits persistent quasi-periodic dimming due to dusty structures close to the star; these may also shadow the disk, producing its observed infrared variability. An FUV spectrum of EP Cha contains Lyman alpha-pumped fluorescent lines from molecular hydrogen in the inner disk gas, and the profiles of these lines contain velocity information uniquely resolvable by COS. Partial shadowing of the disk will induce periodic shifts and distortion of line profiles detectable in time-series spectra, and spatial information about the shadows and disk geometry can be retrieved by a ``tomographic'' analysis. By performing these observations in parallel with TESS this shadowing can be related to the structures responsible for dimming. We will also use the line intensities to reconstruct the Lyman-alpha irradiation and any variation due to intervening gas. This investigation will harness the unique capabilities of HST and build on the Ultraviolet Legacy Library of Young Stars as Essential Standards (ULLYSES).

OBSERVING DESCRIPTION

We will employ the COS G130M (cenwave 1291) and G160M (cenwave 1577) gratings to reach both high spectral resolution and sufficient sensitivity to achieve the needed measurement precision of line profiles. The COS M-modes are chosen over the STIS G140L grating because STIS G140L does not have sufficient spectral resolution to isolate the FUV continuum in molecule-rich disks. TESS will monitor EP Cha during Sector 93 (3-29 June 2025) in Year 7 of its mission, and derived data products will include 200-sec cadence photometry in the TESS bandpass (600-1000 nm), sufficient for resolving any details in the lightcurve. Our COS observing strategy relies on the persistent 2.45-day quasi-periodicity of EP Cha, but we will not know a priori the time of inferior conjunction of an occulting structure. A "desirement" is that all COS observations occur within the same 2.45-day interval, but the requirement is only that they take place within the Sector 93 window and that they are spaced by at least 45 degrees of phase or 5 HST orbits. The number of complete observations (6) is set by the requirement of capturing significant profile variability with a 95% confidence, which Fig. 7b suggests occurs over the superior half of the phase. Paired spectra in the G130M and G160M modes must be taken as closely together as possible to minimize profile variation between them. Integration times are set by the requirement to detect and accurate fit multiple H2 lines and resolve small changes in FWHM of ~10 km/s due to shadowing by a inner disk wall or single occulting structure and thus

achieve a precision of 3 km/s. Assuming 10 lines are averaged and since the median FWHM error in the archival COS spectra is about 15 km/s, this means an increase in SNR by ~50% or about a doubling of the integration times from 1604 and 1306 (for 130M and 160M, respectively) to nearly an hour. EP Cha is at a declination of -78 deg and can be observed for 58 min during an orbit, and minus 7 min for total overhead for target acquisition leaves 3060 sec, sufficient for science integration. We thus propose six visits of two consecutive orbits (G130M+G160M), a total of 12 orbits. COS Instrument Safety: EPCha was safely observed by COS at FUV wavelengths. We have used the STScI on-line Exposure Time Calculators to verify observational safety based on the archival COS spectra. EPCha is well within the safety limit of the COS FUV XDL detector using the COS G130M and COS G160M modes. EP Cha is a K-type star, so flare protection rules imposed for M dwarfs are not applicable.

Visit

Proposal 17760, Visit 01

Tue Aug 13 21:00:36 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: BETWEEN 04-JUN-2025:00:00:00 AND 29-JUN-2025:00:00:00

Fixed Targets

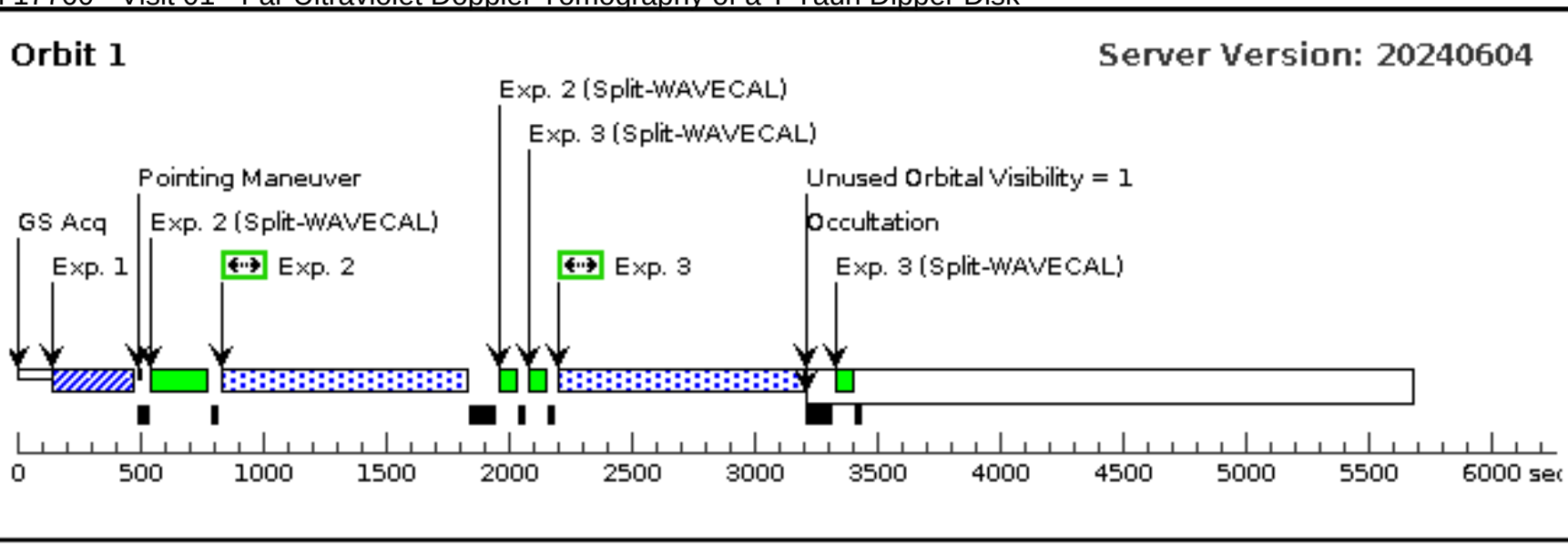
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-EP-CHA	RA: 08 47 1.6440 (131.7568500d) Dec: -78 59 34.38 (-78.99288d) Equinox: J2000	Proper Motion RA: -30.145000000000003 mas/yr Proper Motion Dec: 26.801 mas/yr Parallax: 0.0101198" Epoch of Position: 2000	V=11.1	Reference Frame: ICRS

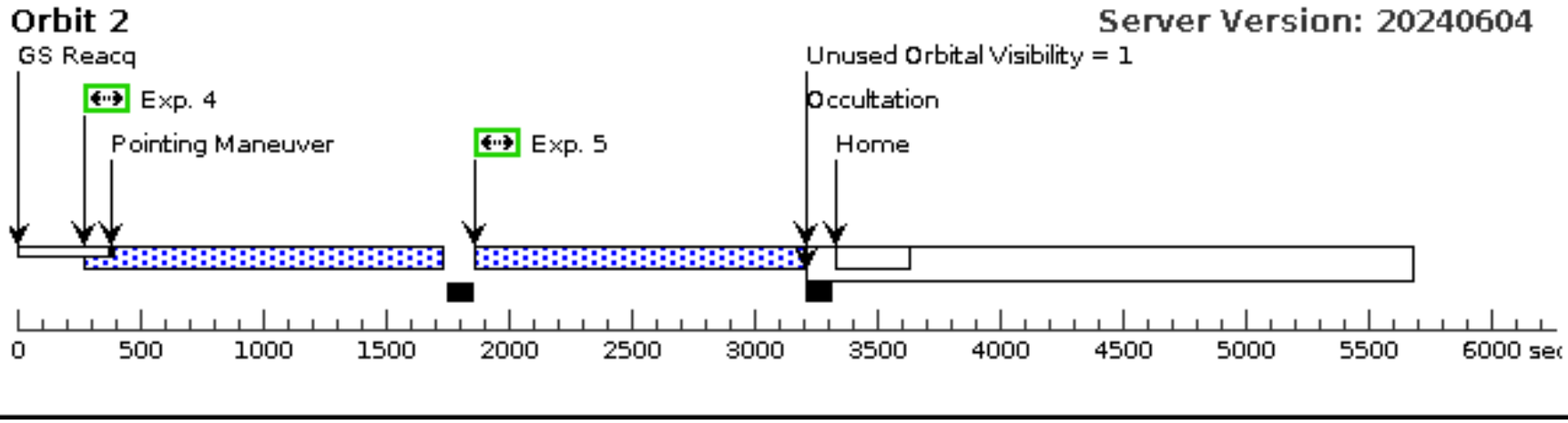
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[T TAURI STAR, YSO]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.im.1931347)	(1) V-EP-CHA	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				20 Secs (20 Secs) *[==>]*	***[1]***
2	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=3; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
3	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=4; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
4	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***
5	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***

Orbit Structure





Visit

Proposal 17760, Visit 02

Tue Aug 13 21:00:36 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: AFTER_01 BY 6_Orbits TO 130_Orbits; BETWEEN 04-JUN-2025:00:00:00 AND 29-JUN-2025:00:00:00

Fixed Targets

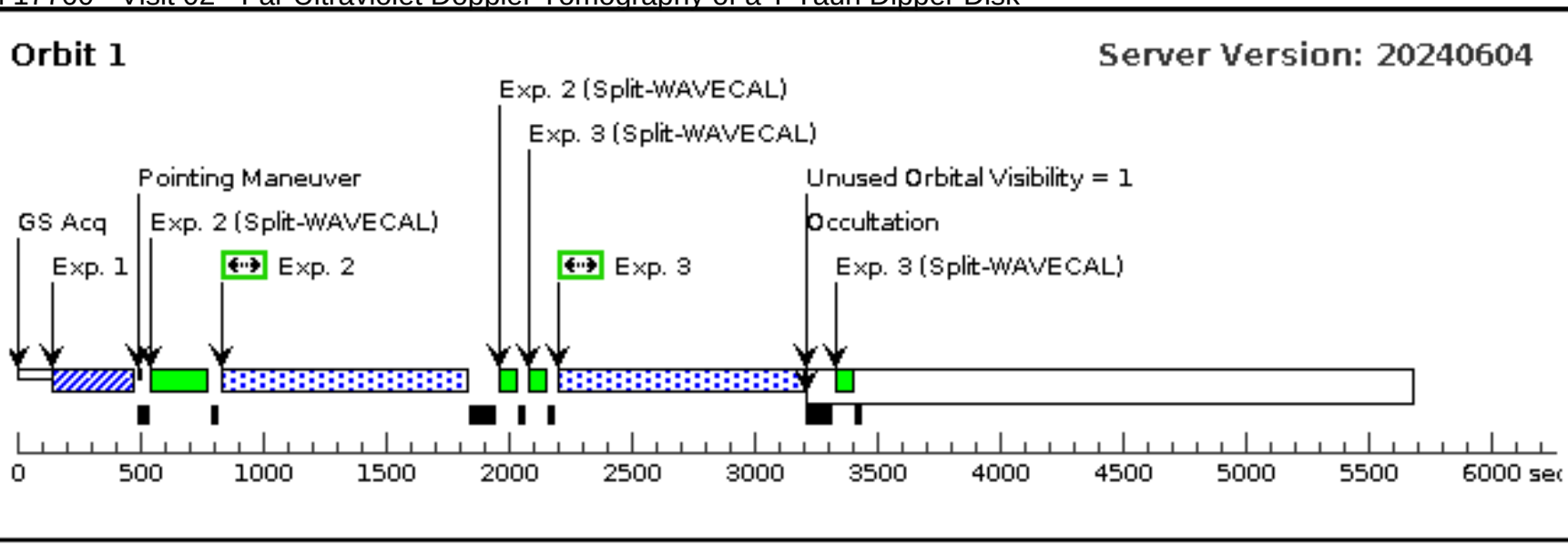
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-EP-CHA	RA: 08 47 1.6440 (131.7568500d) Dec: -78 59 34.38 (-78.99288d) Equinox: J2000	Proper Motion RA: -30.145000000000003 mas/yr Proper Motion Dec: 26.801 mas/yr Parallax: 0.0101198" Epoch of Position: 2000	V=11.1	Reference Frame: ICRS

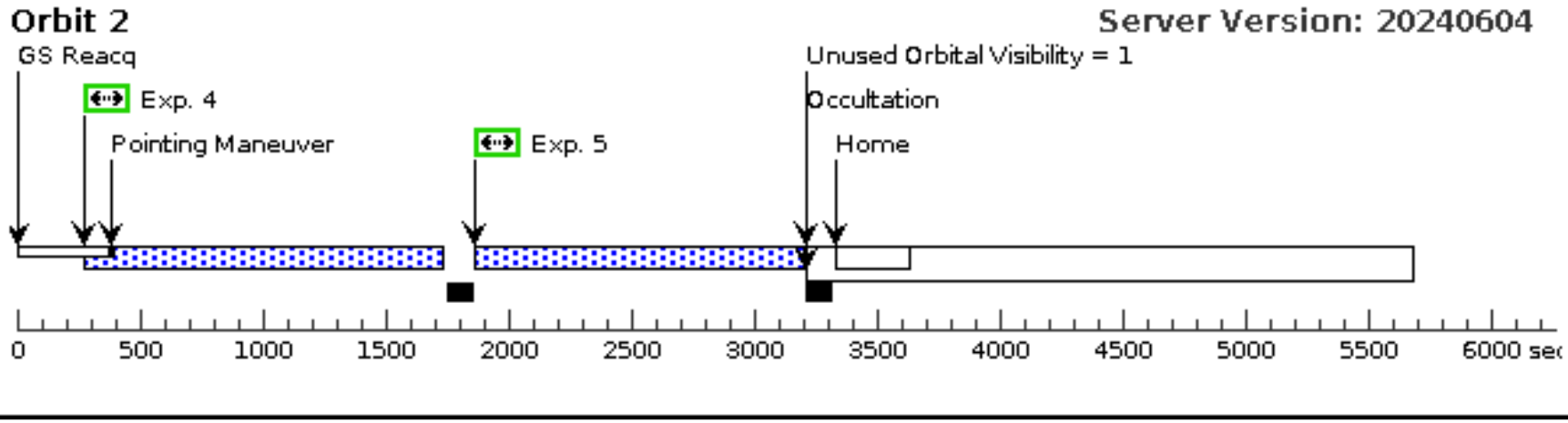
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[T TAURI STAR, YSO]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.im.1931347)	(1) V-EP-CHA	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				20 Secs (20 Secs) *[==>]*	***[1]***
2	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=3; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
3	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=4; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
4	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***
5	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***

Orbit Structure





Visit

Proposal 17760, Visit 03

Tue Aug 13 21:00:36 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: AFTER 02 BY 6 Orbits TO 130 Orbits; BETWEEN 04-JUN-2025:00:00:00 AND 29-JUN-2025:00:00:00

Fixed Targets

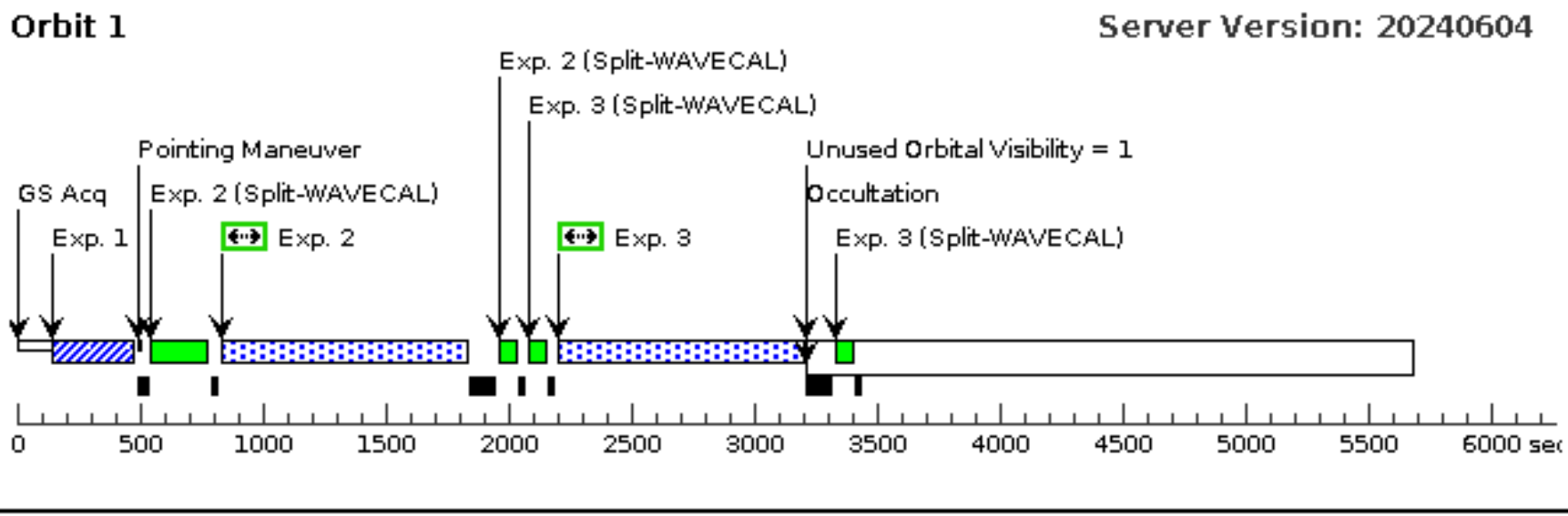
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-EP-CHA	RA: 08 47 1.6440 (131.7568500d) Dec: -78 59 34.38 (-78.99288d) Equinox: J2000	Proper Motion RA: -30.145000000000003 mas/yr Proper Motion Dec: 26.801 mas/yr Parallax: 0.0101198" Epoch of Position: 2000	V=11.1	Reference Frame: ICRS

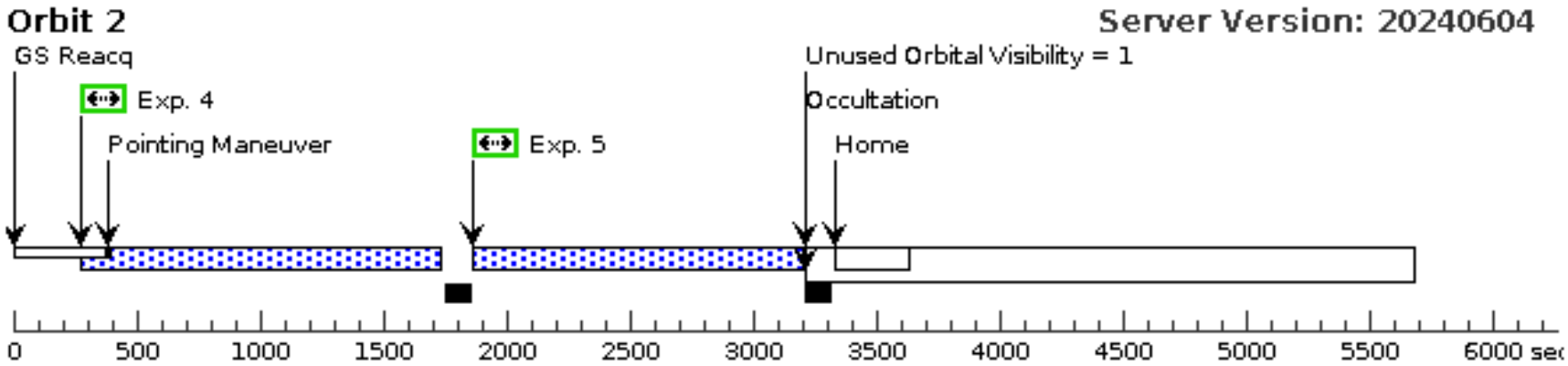
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[T TAURI STAR, YSO]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.im.1931347)	(1) V-EP-CHA	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				20 Secs (20 Secs) *[==>]*	***[1]***
2	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=3; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
3	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=4; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
4	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***
5	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***

Orbit Structure





Visit

Proposal 17760, Visit 04 Tue Aug 13 21:00:36 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: AFTER_03 BY 6_Orbits TO 130_Orbits; BETWEEN 04-JUN-2025:00:00:00 AND 29-JUN-2025:00:00:00

Fixed Targets

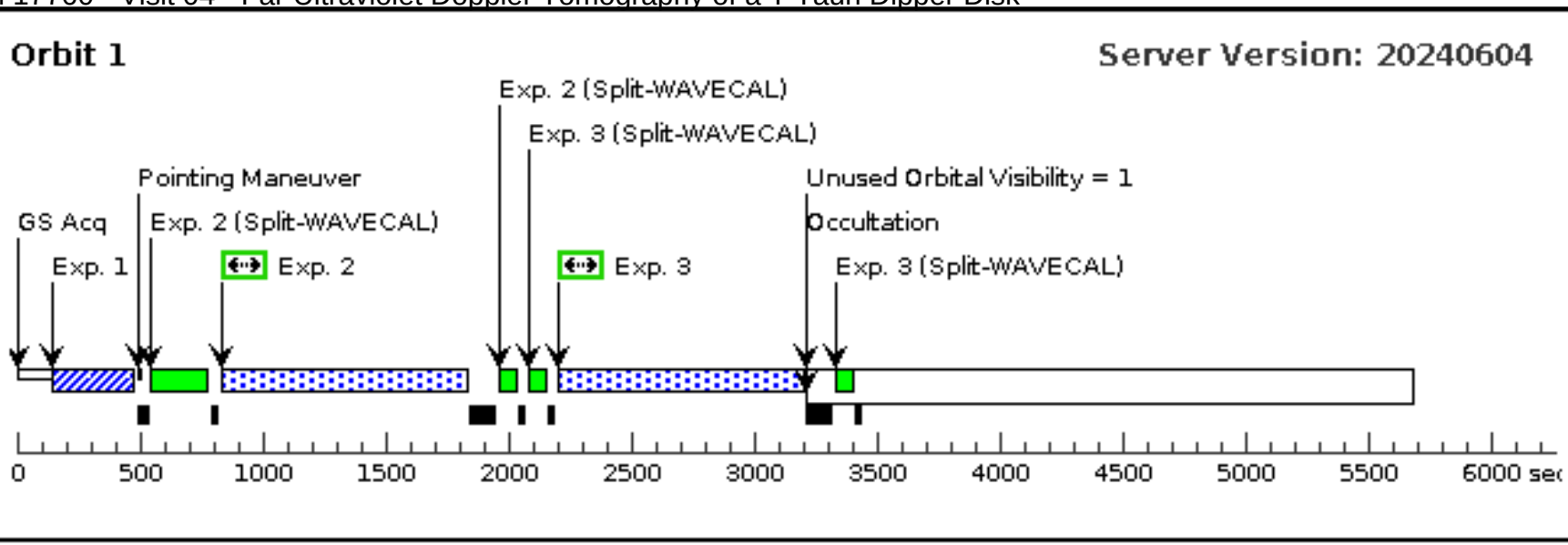
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-EP-CHA	RA: 08 47 1.6440 (131.7568500d) Dec: -78 59 34.38 (-78.99288d) Equinox: J2000	Proper Motion RA: -30.145000000000003 mas/yr Proper Motion Dec: 26.801 mas/yr Parallax: 0.0101198" Epoch of Position: 2000	V=11.1	Reference Frame: ICRS

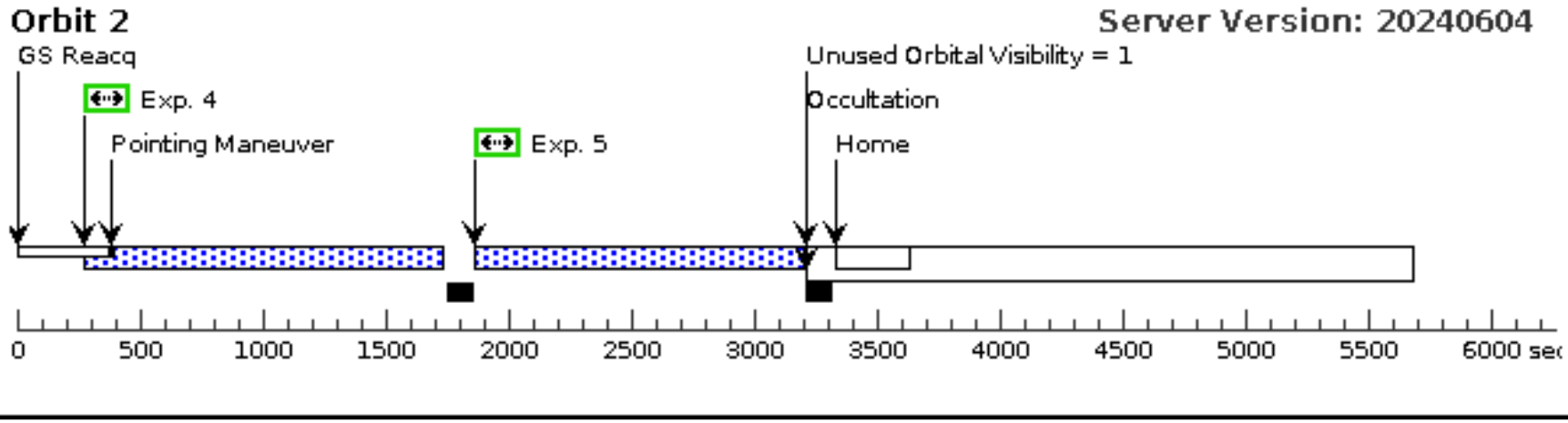
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[T TAURI STAR, YSO]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.im.1931347)	(1) V-EP-CHA	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				20 Secs (20 Secs) *[==>]*	***[1]***
2	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=3; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
3	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=4; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
4	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***
5	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***

Orbit Structure





Visit

Proposal 17760, Visit 05

Tue Aug 13 21:00:36 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: AFTER 04 BY 6 Orbits TO 130 Orbits; BETWEEN 04-JUN-2025:00:00:00 AND 29-JUN-2025:00:00:00

Fixed Targets

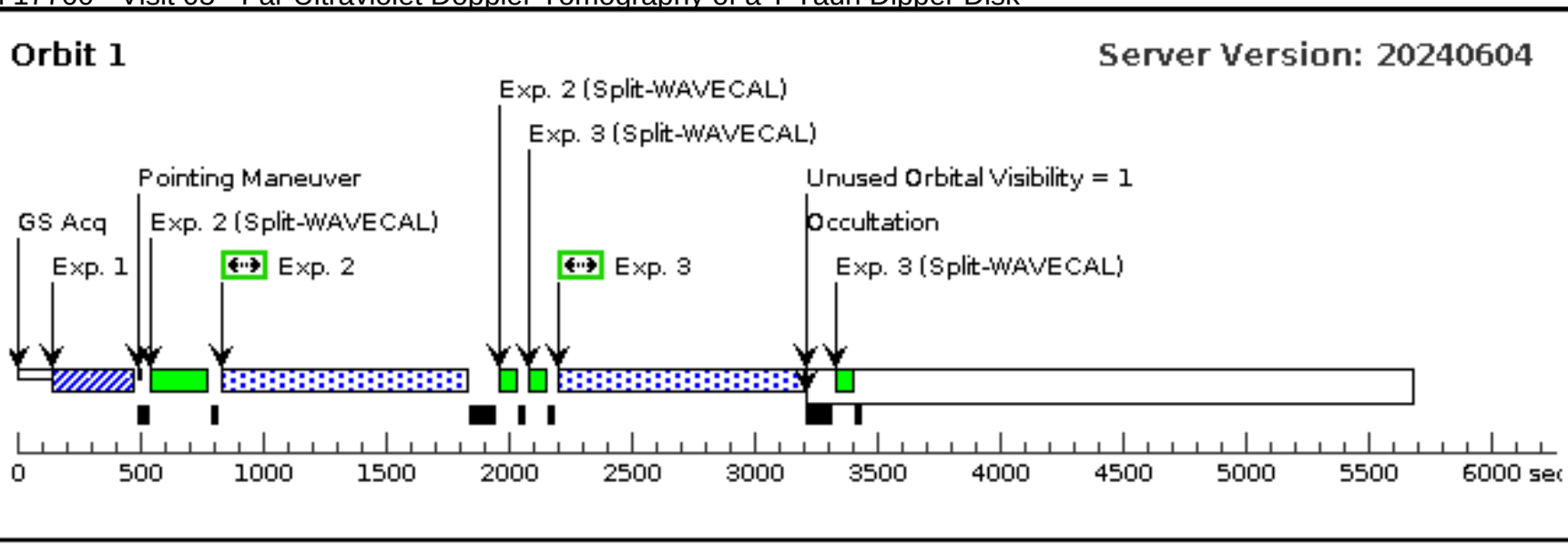
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-EP-CHA	RA: 08 47 1.6440 (131.7568500d) Dec: -78 59 34.38 (-78.99288d) Equinox: J2000	Proper Motion RA: -30.145000000000003 mas/yr Proper Motion Dec: 26.801 mas/yr Parallax: 0.0101198" Epoch of Position: 2000	V=11.1	Reference Frame: ICRS

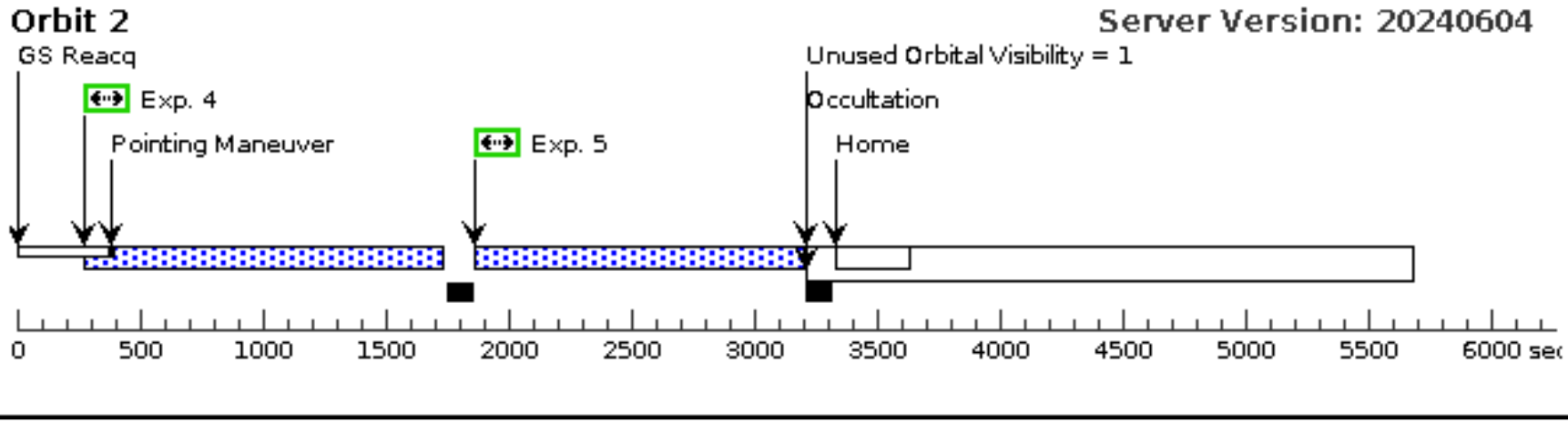
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[T TAURI STAR, YSO]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.im.1931347)	(1) V-EP-CHA	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				20 Secs (20 Secs) *[==>]*	***[1]***
2	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=3; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
3	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=4; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
4	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***
5	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***

Orbit Structure





Visit

Proposal 17760, Visit 06

Tue Aug 13 21:00:36 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: AFTER_05 BY 6_Orbits TO 130_Orbits; BETWEEN 04-JUN-2025:00:00:00 AND 29-JUN-2025:00:00:00

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-EP-CHA	RA: 08 47 1.6440 (131.7568500d) Dec: -78 59 34.38 (-78.99288d) Equinox: J2000	Proper Motion RA: -30.145000000000003 mas/yr Proper Motion Dec: 26.801 mas/yr Parallax: 0.0101198" Epoch of Position: 2000	V=11.1	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[T TAURI STAR, YSO]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (COS.im.1931347)	(1) V-EP-CHA	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				20 Secs (20 Secs) *[==>]*	***[1]***
2	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=3; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
3	Science-G160M (COS.sp.1930486)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G160M 1577 A	BUFFER-TIME=952; FP-POS=4; SEGMENT=BOTH			952 Secs (952 Secs) *[==>]*	***[1]***
4	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***
5	Science-G130M (COS.sp.1930485)	(1) V-EP-CHA	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=1285; SEGMENT=BOTH			1285 Secs (1285 Secs) *[==>]*	***[2]***

Orbit Structure