12199 - The shocking truth about DG Tau's jet

Cycle: 18, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) DG-TAU	STIS/CCD STIS/FUV-MAMA	5	06-Dec-2010 14:56:11.0	yes
02	(1) DG-TAU	STIS/CCD	1	06-Dec-2010 14:56:13.0	yes
03	(1) DG-TAU	ACS/SBC	2	06-Dec-2010 14:56:14.0	yes

8 Total Orbits Used

ABSTRACT

We propose to use STIS to obtain the first FUV long-slit spectrum of DG Tau's jet. The classical T Tauri star DG Tau shows signatures of magnetic activity, accretion, a circumstellar disk and outflows. The detection of soft X-ray emission from hot plasma with temperatures above 1E6 K within DG Tau's jet at a few tens of AU from the power source, distinctly different from coronal emission, challenges current jet theories, since observations

and modeled scenarios concentrated on warm material with temperatures up to a few 1E4 K.

With the slit oriented along the jet axis and supplementary broad band ACS/SBC FUV images, we will use the C IV emission line doublet (peak formation temperature 1E5 K) to measure, for the first time, the kinematics of the intermediate temperature gas along the jet axis, which is not possible with any other instrument. Our goals are to find (1) the relation of the intermediate temperature material to the hot X-ray emitting material, (2) the correlation of temperature and velocity in stellar jets, and (3) the heating source of the hotter material.

OBSERVING DESCRIPTION

The goal of the proposed observations is to spatially resolve the kinematics of the intermediate temperature material (T=1E5 K) within DG Tau's jet. The proposed observations concentrate on the strong C IV emission line doublet (~1550 Ang).

Short description:

The program consists of three parts.

1. STIS FUV MAMA long-slit spectroscopy with the slit-orientation along the jet axis (wavelengths 1513-1567 Ang).
2. ACS/SBC FUV images covering a larger region around the jet.
3. STIS CCD optical long-slit spectroscopy with the same orientation as the FUV long-slits for a correlation of warm (1E4 K) and hotter (1E5 K) gas.

Detailed description:

STIS FUV MAMA long-slit spectra:

The position angle of the jet (PA=226D) is known from previous observations (HST and ground based AO). Since we expect the highest velocity component, which is concentrated on the jet axis, to be related to the C IV emission, a tolerance of plus/minus 1D in position angle is acceptable for this jet and the 52"x0.2" slit should include most of the emission due to the onion-like velocity structure of the jet.

Setting the G140M grating to the wavelength range 1513-1567 Ang includes the C IV emission line doublet (1548 and 1551 Ang) and ro-vibrationally excited molecular H emission at 1521 Ang and 1525 Ang.

A short ACQ exposure (STIS CCD with F28X50LP filter) is needed to center the jet in the slit. We will also take a short (1 min) exposure with the G430L grating in order to identify any exceptionally low or high accretion states of DG Tau.
Then the detector will be changed to MAMA, while the star can reside centered since no (strong) C IV emission is expected from DG Tau. The central source is absorbed and no emission has been detected in the small aperture STIS observation centered on DG Tau.

Our exposure time calculation is based on the measured C IV flux from the HST GHRS observation (approx 2E-14 erg/s/Ang/cm^2, FWHM 1 Ang). The continuum emission at these wavelengths is very weak (less than 10 %) compared to the line emission we utilize. Without any specific knowledge of the extent of the source, we assume that the measured flux originates from an extended region of about 0.2 arcsec^2. This is consistent with our knowledge from existing X-ray observations and the extent of the high velocity component close to DG Tau. Using the STIS ETC we find an exposure time of about 210 min for S/N=10. Including the non-scientific overhead, we need five orbits.

Optical long-slit spectra:
The optical long-slit exposure (STIS G750M CCD) resembles the Bacciotti et al. 2000 observation (3x900 s exposures, i.e., one orbit). The only difference is that we will use the wider 52"x0.2" slit. Dedicating one orbit to this exposure will enable us to compare the C IV emission with that of lower temperature ions like [N II] and [O I].

ACS/SBC images:
For the ACS images, we choose an extraction region of 3x3 pixel corresponding to a spatial scale of 0.1 arcsec which is sufficient for our goals. We will need three images with the long-band pass filters F140LP, F150LP and F165LP. Detailed molecular hydrogen modeling as done by Herczeg et al. 2006 will allow us to account for the molecular hydrogen emission in the F150LP filter from the F140LP image. The F165LP exposure will constrain the emission at longer wavelengths different from C IV emission. Therefore, this combination allows us to construct an image of the jet in the C IV lines. For our exposure time calculation, we consider extended structures of about a tenth of the surface brightness of the expected peak emission which is about the ratio of the inner and the outer X-ray emission. For a S/N of 10, we obtain an exposure time of 30 min each, i.e., two orbits.

Detector safety:
For the discussion of the detector safety, we'll concentrate on the ACS/SBC images since the STIS/FUV-MAMA long-slit spectra have a lower efficiency while the detector has a comparable count-rate limit.

DG Tau itself has been observed in the FUV with IUE and HST and shows essentially only emission lines. We provide two figures showing the measured fluxes in the wavelength ranges covered by all observations (1536-1570 Ang, 1383-1418 Ang).
The IUE and GHRS spectra are of the best quality and yield rather similar fluxes, the mean flux values in the overlapping regions coincide within a factor of two (1550 A: 2.4,3.2 and 4.2 in 1E-15 erg/s/A/cm^2, 1400 A: 1.2,1.9 and 1.4 in 1E-15 erg/s/A/cm^2). The STIS E140M spectrum obtained through the 0.2"x0.06" slit shows a much lower flux which we take as an indication that "DG Tau's" FUV emission is spatially extended.
Using the brightest IUE spectrum in the exposure time calculator, the predicted count-rate is 8.8 counts/sec (1x1 pixel region, replacing negative flux values with zeros) and thus within the bright object limits for the ACS/SBS combination (50 cts/s for a constant, 20 cts/s for a variable source). However, if this estimate is too close to the safety-limit given the possible source variability, the STIS long-slit spectra can be obtained before the ACS/SBC images and thereby checking the current luminosity and extent of the FUV emission.

The BOT reports two unknown sources in the field of view. While one is of 20th magnitude (N9QL001759) and therefore safe to observe, the other one (N9QL009269) has a reported photometric J-magnitude of 10.02, its distance from DG Tau is approximately 7-8". Such a source is not known although it should have been clearly detected with the available observations. We suspect that this source is DG Tau itself which has a similar magnitude (V~12.3 mag, Hartigan et al. 1995, Kenyon & Hartmann 1995, resp).

The field has been observed in the U-band with the Optical Monitor onboard of XMM-Newton (Obs-ID 0203540201). The image covers the safety region (70" diameter) requested for the checks. DG Tau has an U-band magnitude of 13.57, (Audard et al. 2007) and the background-level in the image is approximately U=19.0 mag. No source different from DG Tau is visible in this image. Since the limiting magnitude of the ACS/ABC F140LP is V=18.5 mag for an O5 star, the field is safe to observe (a hypothetical O5-star has U-V ~ -1.5 mag). The other filters we use (F150LP, F165LP) have lower limiting magnitudes and are likewise safe.

ADDITIONAL COMMENTS

We prefer the observations to be performed during the visibility period between approximately Sept. 2010 and Feb. 2011 to ensure a temporal correlation with the recent Chandra X-ray large program.
The timespan between the individual visits should be kept short since jet structures move with velocities of up to ~0.06 arcsec per month. Therefore, we included the "group within 30 days" requirement which we might loosen slightly for a different grouping of the exposures.

Visit

Proposal 12199, Visit 01, implementation Mon Dec 06 19:56:15 GMT 2010

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/FUV-MAMA, STIS/CCD

Special Requirements: ORIENT 90D TO 92 D; GROUP 01,02 WITHIN 30D

Comments: The FUV long-slit spectra with STIS FUV MAMA. The slit should be oriented along the jet axis. Position Angle of the jet is 226 degree (south-west).
ORIENT=270-272 is also possible but not our preferred solution and we would offset DG Tau closer to the pseudo-aperture D1 in that case.

Fixed Targets

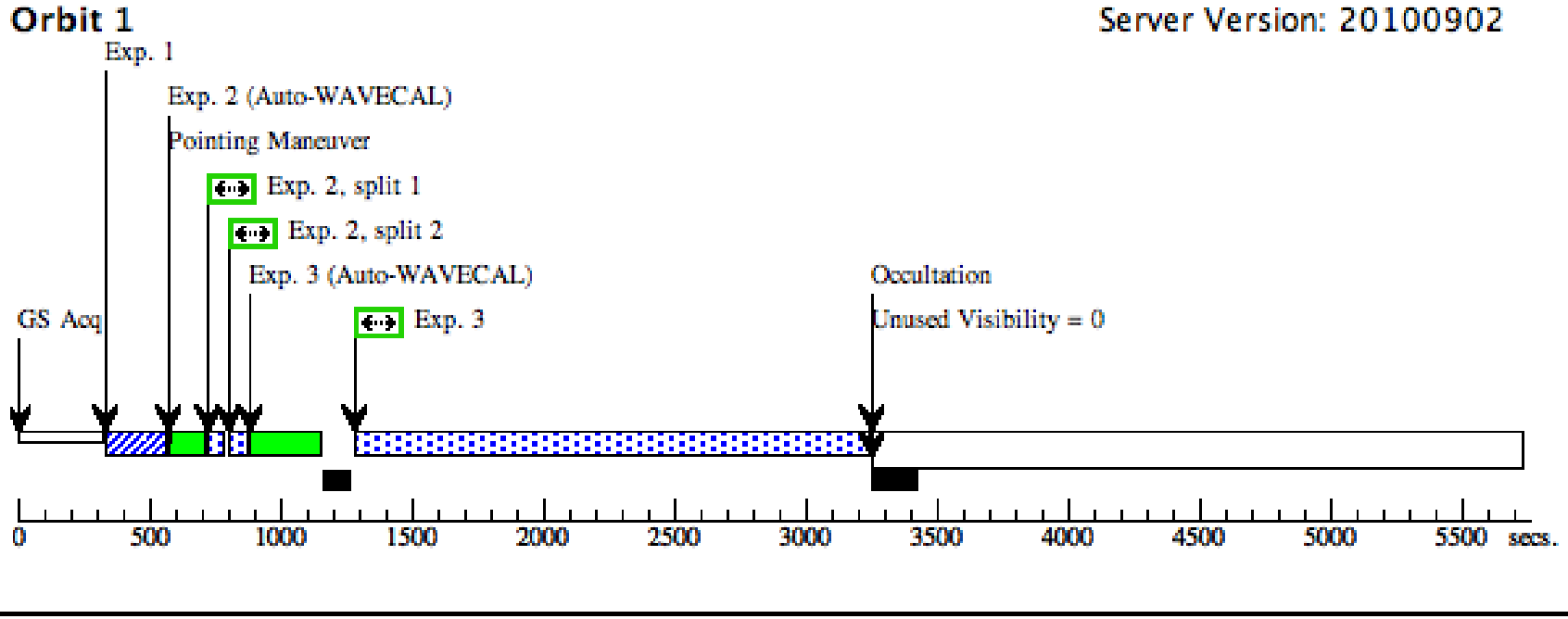
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	DG-TAU Alt Name1: IRAS04240+2559 Alt Name2: GSC01820-00330	RA: 04 27 4.7000 (66.7695833d) Dec: +26 06 16.30 (26.10453d) Equinox: J2000	Proper Motion RA: null Proper Motion Dec: null Epoch of Position:	V=10.5+/- F-LINE(1550)=2+-2E-14, F-CONT(1550)=2+-2E-15, W-LINE(1550)=1.0+-1.0	Reference Frame: ICRS

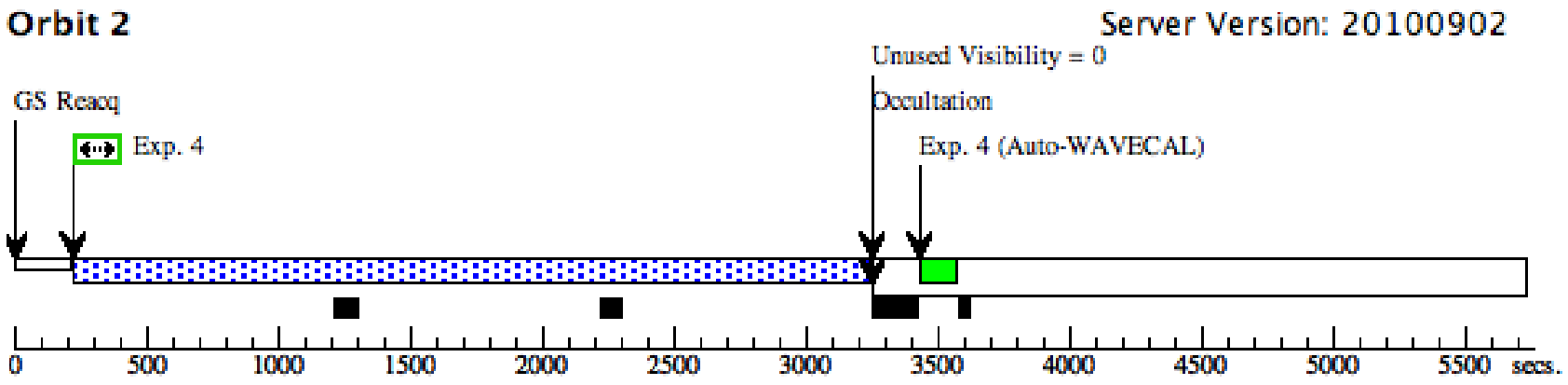
Comments: The coordinates are for the star itself. We want to observe the inner part of the jet which has a position angle of 226 degree (i.e. SW). Coordinates are from 2MASS. GSC1: PLATE-ID=000L.
The V-magnitude is for DG Tau which has A_V~1.6 (spectral type ~K7).
Position uncertainties were estimated from the difference between previous HST DG Tau observations and the 2MASS position. Fluxes pertain to the each of the C IV emission lines.

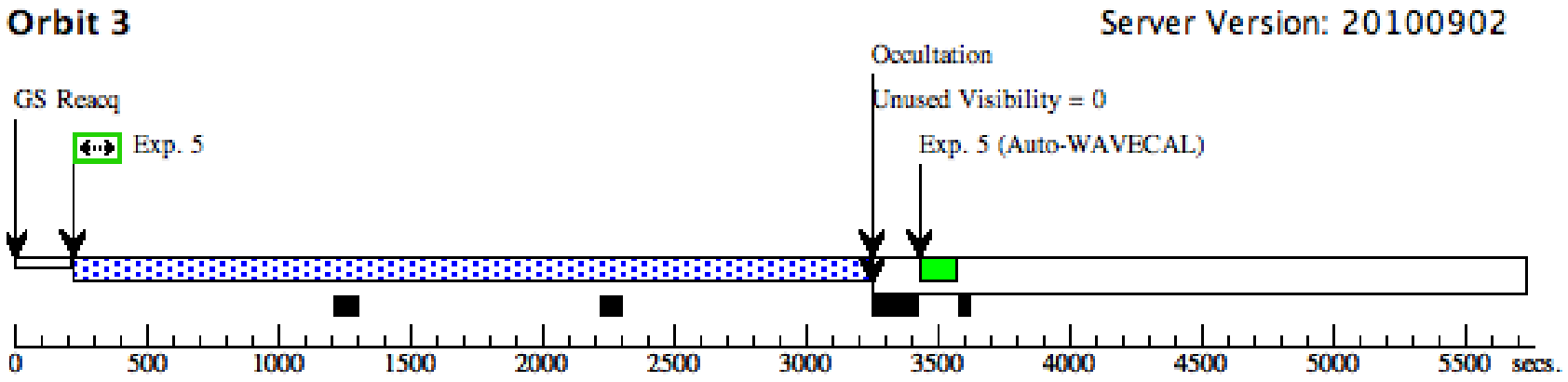
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	ACQ for FUV long-slits	(1) DG-TAU	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT	GS ACQ SCENARIO BASE1B3		0.2 Secs *[==>]*	 ***[1]***
2	G430L	(1) DG-TAU	STIS/CCD, ACCUM, 52X0.2	G430L 4300 A	CR-SPLIT=2			60 Secs *[==>(Split 1)]* *[==>(Split 2)]*	 ***[1]***
3	FUV long-slit, Part1	(1) DG-TAU	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140M 1540 A	BUFFER-TIME=1000			2000 Secs *[==>1943.0 Secs]*	 ***[1]***
4	FUV long-slit, Part2	(1) DG-TAU	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140M 1540 A	BUFFER-TIME=1000			3005 Secs *[==>]*	 ***[2]***
5	FUV long-slit, Part3	(1) DG-TAU	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140M 1540 A	BUFFER-TIME=1000			3005 Secs *[==>]*	 ***[3]***
6	FUV long-slit, Part4	(1) DG-TAU	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140M 1540 A	BUFFER-TIME=1000			3005 Secs *[==>]*	 ***[4]***
7	FUV long-slit, Part5	(1) DG-TAU	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140M 1540 A	BUFFER-TIME=1000			3005 Secs *[==>]*	 ***[5]***

Orbit Structure



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Occultation
GS Reacq
Unused Visibility = 0
Exp. 5
Exp. 5 (Auto-WAVECAL)
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1000
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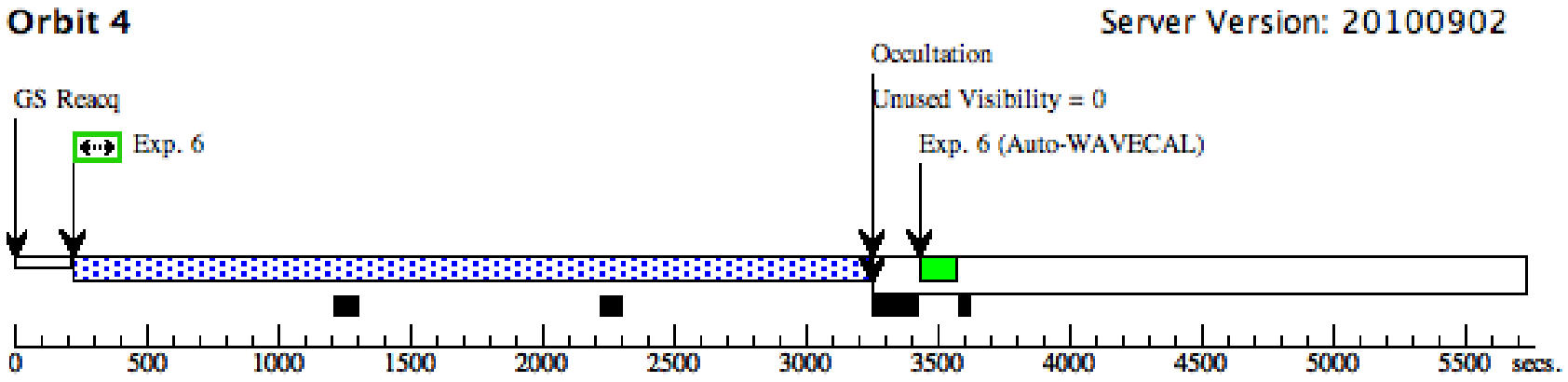
3000
3500
4000
4500
5000
5500
secs.


Orbit 4
Server Version: 20100902
Occultation
GS Reacq
Unused Visibility = 0
Exp. 6
Exp. 6 (Auto-WAVECAL)
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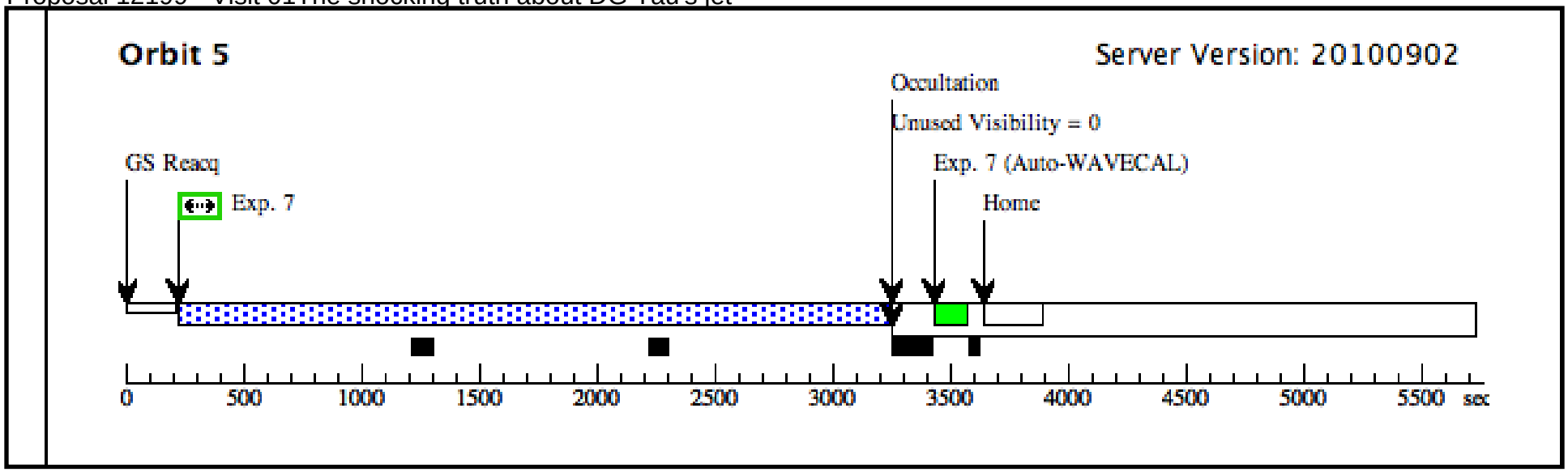
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 5
Server Version: 20100902
Occultation
Unused Visibility = 0
GS Reacq
Exp. 7
Exp. 7 (Auto-WAVECAL)
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 12199, Visit 02, implementation Mon Dec 06 19:56:16 GMT 2010

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: ORIENT 90D TO 92 D; GROUP 02,01 WITHIN 30D

Comments: The optical long-slit spectrum with the slit oriented along the jet-axis (PA=226 degree).
ORIENT=270-272 is also possible but not our preferred solution.

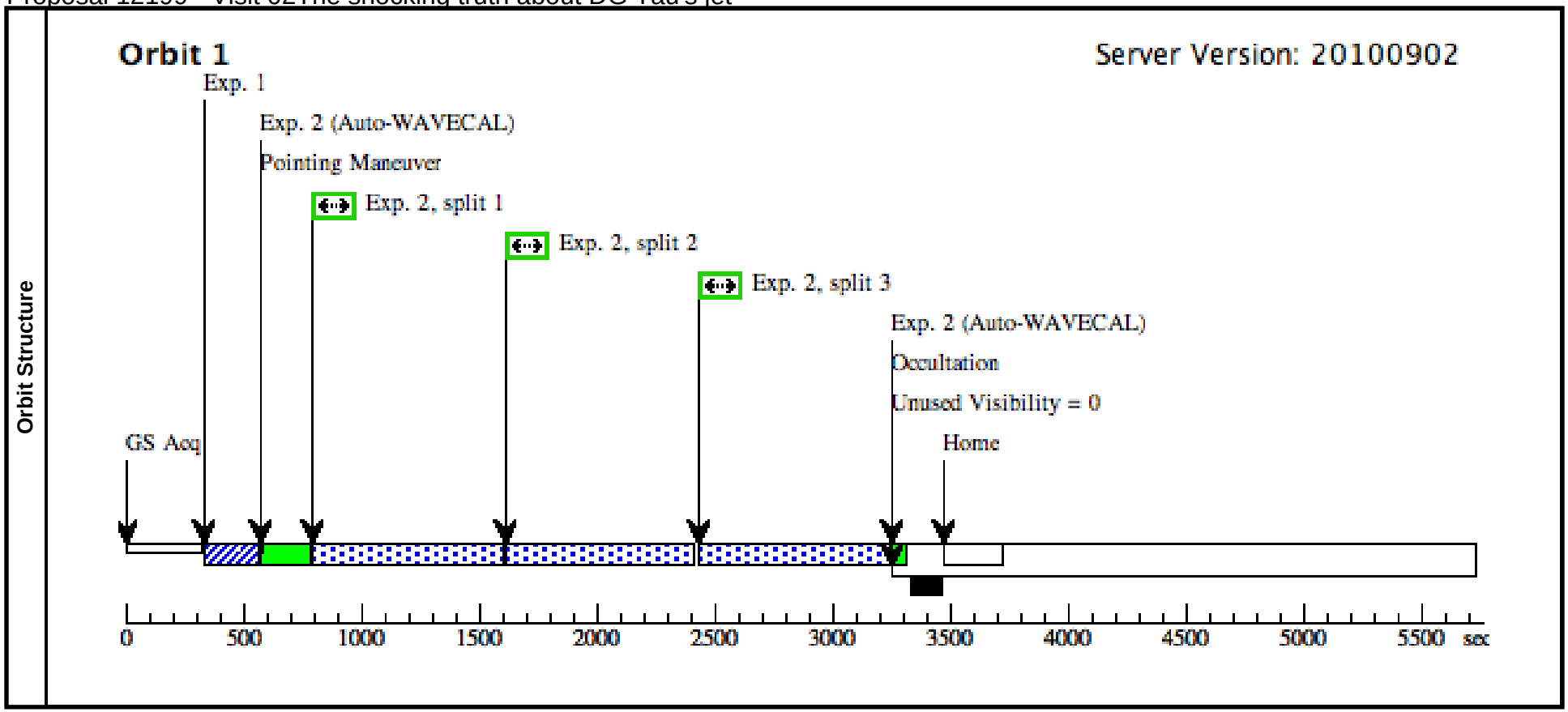
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	DG-TAU Alt Name1: IRAS04240+2559 Alt Name2: GSC01820-00330	RA: 04 27 4.7000 (66.7695833d) Dec: +26 06 16.30 (26.10453d) Equinox: J2000	Proper Motion RA: null Proper Motion Dec: null Epoch of Position:	V=10.5+/- F-LINE(1550)=2+-2E-14, F-CONT(1550)=2+-2E-15, W-LINE(1550)=1.0+-1.0	Reference Frame: ICRS

Comments: The coordinates are for the star itself. We want to observe the inner part of the jet which has a position angle of 226 degree (i.e. SW). Coordinates are from 2MASS. GSC1: PLATE-ID=000L.
The V-magnitude is for DG Tau which has A_V~1.6 (spectral type ~K7).
Position uncertainties were estimated from the difference between previous HST DG Tau observations and the 2MASS position. Fluxes pertain to the each of the C IV emission lines.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Aquisition for optical long-slit	(1) DG-TAU	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT	GS ACQ SCENARIO BASE1B3		0.2 Secs *[==>]*	***[1]***
2	accum for optical long-slit	(1) DG-TAU	STIS/CCD, ACCUM, 52X0.2	G750M 6581 A	CR-SPLIT=3			2000.0 Secs *[==>774.0 Secs (Split 1)]* *[==>774.0 Secs (Split 2)]* *[==>774.0 Secs (Split 3)]*	***[1]***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Server Version: 20100902
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Exp. 2 (Auto-WAVECAL)
Pointing Maneuver
Exp. 2, split 1
Exp. 2, split 2
Exp. 2, split 3
Exp. 2 (Auto-WAVECAL)
Occultation
Unused Visibility = 0
GS Acq
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 12199, Visit 03, scheduling Mon Dec 06 19:56:16 GMT 2010

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/SBC

Special Requirements: (none)

Comments: The long band-pass FUV images

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	DG-TAU Alt Name1: IRAS04240+2559 Alt Name2: GSC01820-00330	RA: 04 27 4.7000 (66.7695833d) Dec: +26 06 16.30 (26.10453d) Equinox: J2000	Proper Motion RA: null Proper Motion Dec: null Epoch of Position:	V=10.5+/- F-LINE(1550)=2+-2E-14, F-CONT(1550)=2+-2E-15, W-LINE(1550)=1.0+-1.0	Reference Frame: ICRS

Comments: The coordinates are for the star itself. We want to observe the inner part of the jet which has a position angle of 226 degree (i.e. SW). Coordinates are from 2MASS. GSC1: PLATE-ID=000L.
The V-magnitude is for DG Tau which has A_V~1.6 (spectral type ~K7).
Position uncertainties were estimated from the difference between previous HST DG Tau observations and the 2MASS position. Fluxes pertain to the each of the C IV emission lines.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	ACS F140L P Part1	(1) DG-TAU	ACS/SBC, ACCUM, SBC	F140LP				900 Secs *[==>939.0 Secs]*	 ***[1]***
2	ACS F140L P Part2	(1) DG-TAU	ACS/SBC, ACCUM, SBC	F140LP				900 Secs *[==>940.0 Secs]*	 ***[1]***
3	ACS F150L P Part1	(1) DG-TAU	ACS/SBC, ACCUM, SBC	F150LP				1800 Secs *[==>866.0 Secs]*	 ***[1]***
4	ACS F150L P Part2	(1) DG-TAU	ACS/SBC, ACCUM, SBC	F150LP				1800 Secs *[==>1014.0 Secs]*	 ***[2]***
5	ACS F165L P Part1	(1) DG-TAU	ACS/SBC, ACCUM, SBC	F165LP				900 Secs *[==>940.0 Secs]*	 ***[2]***
6	ACS F165L P Part2	(1) DG-TAU	ACS/SBC, ACCUM, SBC	F165LP				900 Secs *[==>939.0 Secs]*	 ***[2]***

Orbit Structure