12610 - Convection and mass loss through the chromosphere of Betelgeuse

Cycle: 19, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Stephen T. Ridgway (PI)	**National Optical Astronomy Observatory, AURA**	**ridgway@noao.edu**
Dr. Pierre Kervella (CoI) (ESA Member) (Contact)	Observatoire de Paris	pierre.kervella@obspm.fr
Dr. Andrea Chiavassa (CoI) (ESA Member)	Universite Libre de Bruxelles	achiavas@ulb.ac.be
Dr. Xavier Haubois (CoI)	Universidade de Sao Paulo	xhaubois@astro.iag.usp.br
Dr. Guy Perrin (CoI) (ESA Member)	Observatoire de Paris	guy.perrin@obspm.fr
Mr. Miguel Montarges (CoI) (ESA Member)	Observatoire de Paris	miguel.montarges@obspm.fr

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) BETELGEUSE	STIS/FUV-MAMA STIS/NUV-MAMA	2	04-Jan-2012 21:11:48.0	yes
02	(1) BETELGEUSE	STIS/FUV-MAMA STIS/NUV-MAMA	1	04-Jan-2012 21:11:56.0	yes
03	(1) BETELGEUSE	STIS/FUV-MAMA STIS/NUV-MAMA	2	04-Jan-2012 21:12:04.0	yes
04	(2) HD38393	STIS/FUV-MAMA STIS/NUV-MAMA	1	04-Jan-2012 21:12:11.0	yes

6 Total Orbits Used

ABSTRACT

Betelgeuse is well suited for detailed study of the mass loss process in a massive red supergiant. We have engaged in a multi-scale, multi-color study to trace the ejected material from the photosphere to the interstellar medium, and understand its chemical evolution (formation of molecules and dust). Infrared interferometry already gave us a detailed image of the photosphere, compatible with large convective cells. Adaptive optics spectro-imaging (1.0-2.2 microns) allowed us to detect the presence of the CN molecule and mass loss plume structures up to at least 6 R*. At larger distances, we observed silicate-rich dust in thermal IR (8-20 microns). From the surface to 100 R*, we therefore have a continuous coverage with multicolor imagery. The chromosphere lies at a key location, between the photosphere and the molecular envelope. As shown by STIS spatially resolved spectroscopy (Lobel & Dupree 2001), it contains rising and falling gases. Such structure is supported by our 3D modeling of the convection. In order to probe the dynamics of the envelope and its relation to photospheric spots and mass loss plumes, we propose to obtain UV imaging with STIS at 3 epochs to complement our coordinated ground-based effort as well as the earlier HST UV snapshots. We will use this imagery to correlate structures at different radii and temperatures, and to explore the time-scales of evolution. With the support of our 3D models, this information will answer specific questions including deciding between convective and polar explanations for bright spots and plumes. Our infrared imaging observations will be repeated contemporaneously with the requested HST/STIS images.

OBSERVING DESCRIPTION

We will observe Betelgeuse:
- at two epochs with STIS-MAMA in three filters (FUV-F25LYA, FUV-F25NDQ1, NUV-F25ND5),
- at one epoch with STIS-MAMA in two filters (FUV-F25NDQ1, NUV-F25ND5)

We will also observe a PSF calibrator, HD 38393, at one epoch, in three filters (FUV-F25LYA, FUV-F25NDQ1, NUV-F25ND5).

The observations of Betelgeuse and the PSF calibrator in the F25NDQ1 and F25ND5 filters will be dithered with 1.5-pixel steps to obtain a better PSF sampling.

Proposal 12610 - Visit 01 - Convection and mass loss through the chromosphere of Betelgeuse

Visit

Proposal 12610, Visit 01, implementation Thu Jan 05 02:12:15 GMT 2012

Diagnostic Status: No Diagnostics

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

Special Requirements: (none)

Comments: This is a three-filter exposure on Betelgeuse (FUV-F25LYA, FUV-F25NDQ2, NUV-F25ND5), spread over 2 orbits.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=STIS-MAMA-BOX	Coordinate Frame=POS-TARG		(2), (3)
	Purpose=DITHER	Pattern Orientation=26.6		
	Number Of Points=4	Angle Between Sides=143.130102		
	Point Spacing=0.0369	Center Pattern=false		
	Line Spacing=0.0369			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	BETELGEUSE	RA: 05 55 10.3053 (88.7929388d)	Proper Motion RA: 27.54 mas/yr	V=0.7+/-0.5	Reference Frame: ICRS
	Alt Name1: ALPHA-ORI	Dec: +07 24 25.43 (7.40706d)	Proper Motion Dec: 11.30 mas/yr	magU = 4.38,	
	Alt Name2: HD39801	Equinox: J2000	Parallax: 0.00655"	magB = 2.27,	
			Epoch of Position: 2000	E(B-V)=0.4699	
			Radial Velocity: 21.91 km/sec		

Comments: Betelgeuse is an irregular, moderately variable star. Its current (Dec 2011) V band magnitude according to the AAVSO, is mV=0.45, i.e. slightly above its average brightness over the last 10 years (mV ~0.5, with an evolution range between 0.3 and 1.0).

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Bet-FUV-F25LYA (185981)	(1) BETELGEUSE	STIS/FUV-MAMA, TIME-TAG, F25LYA	MIRROR	BUFFER-TIME=4000			2800 Secs *[==>2751.0 Secs]*	 ***[1]***

Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is similar to a STIS-MAMA F25LYA exposure in TIME-TAG mode (EXPTIME=2300s) obtained on 2000-03-14 on Betelgeuse with STIS in the same configuration (exposure id: o55001d7q), that gave a maximum flux of 200 counts/s on the star, and a total flux of 1450 counts/s on the MAMA array. This figure is comparable to out result using the STIS imaging ETC (1870 counts/s).
The corresponding BUFFER-TIME parameter is therefore 2e6/1870 = 1070 s. With a further safety margin of 20%, we obtain a BUFFER-TIME value of 855 s.

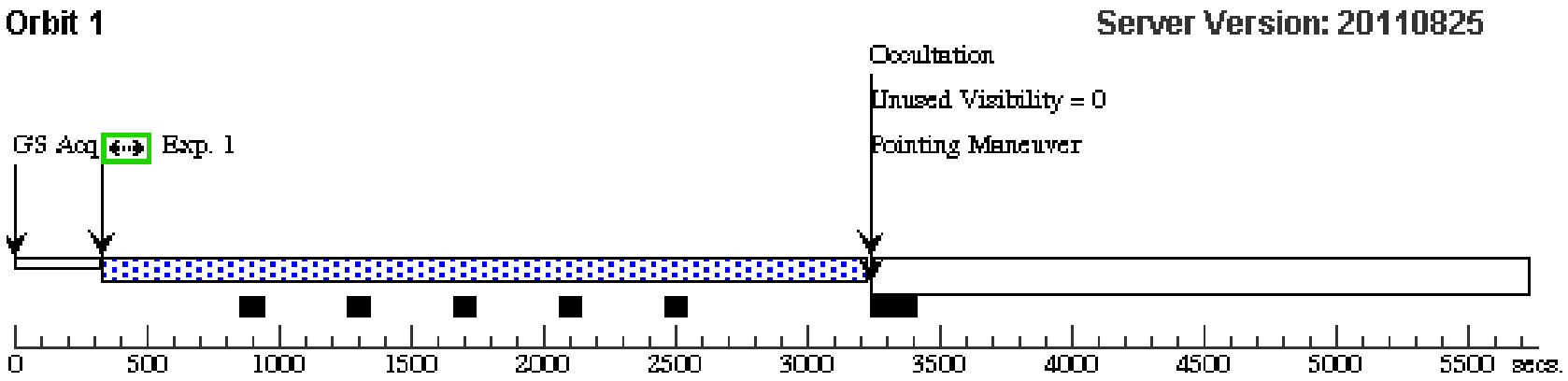
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
2	Bet-FUV-F25NDQ2 (185983)	(1) BETELGEUSE	STIS/FUV-MAMA, ACCUM, F25NDQ2	MIRROR			Pattern 1, Exps 2-2 in Visit 01 (1)	120 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	 ***[2]***

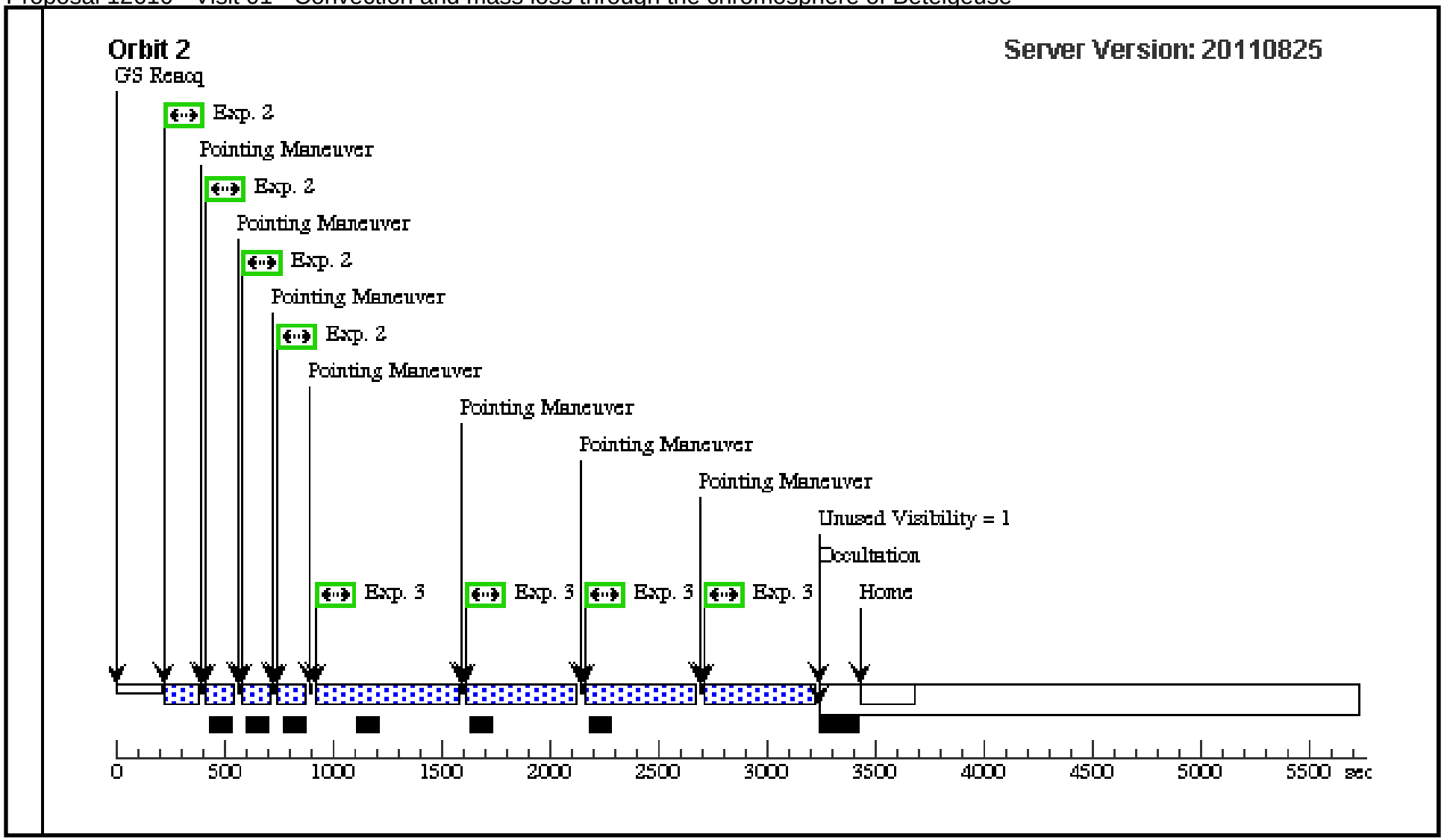
Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is split in four sub-exposures to allow dithering with an amplitude of 1.5 pixels.

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
3	Bet-NUV-F25ND5 (185984)	(1) BETELGEUSE	STIS/NUV-MAMA, ACCUM, F25ND5	MIRROR			Pattern 1, Exps 3-3 in Visit 01 (1)	500 Secs *[==>479.0 Secs (Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	 ***[2]***

Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is split in four sub-exposures to allow dithering with an amplitude of 1.5 pixels.

Orbit Structure




Orbit 2
Server Version: 20110825
GS Reacq
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 1
Occultation
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Proposal 12610 - Visit 02 - Convection and mass loss through the chromosphere of Betelgeuse

Visit

Proposal 12610, Visit 02, implementation Thu Jan 05 02:12:16 GMT 2012

Diagnostic Status: No Diagnostics

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

Special Requirements: AFTER 01 BY 15 D TO 45 D

Comments: Two-filter exposure on Betelgeuse, over a 1 orbit visit.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=STIS-MAMA-BOX	Coordinate Frame=POS-TARG		(1), (2)
	Purpose=DITHER	Pattern Orientation=26.6		
	Number Of Points=4	Angle Between Sides=143.130102		
	Point Spacing=0.0369	Center Pattern=false		
	Line Spacing=0.0369			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	BETELGEUSE	RA: 05 55 10.3053 (88.7929388d)	Proper Motion RA: 27.54 mas/yr	V=0.7+/-0.5	Reference Frame: ICRS
	Alt Name1: ALPHA-ORI	Dec: +07 24 25.43 (7.40706d)	Proper Motion Dec: 11.30 mas/yr	magU = 4.38,	
	Alt Name2: HD39801	Equinox: J2000	Parallax: 0.00655"	magB = 2.27,	
			Epoch of Position: 2000	E(B-V)=0.4699	
			Radial Velocity: 21.91 km/sec		

Comments: Betelgeuse is an irregular, moderately variable star. Its current (Dec 2011) V band magnitude according to the AAVSO, is mV=0.45, i.e. slightly above its average brightness over the last 10 years (mV ~0.5, with an evolution range between 0.3 and 1.0).

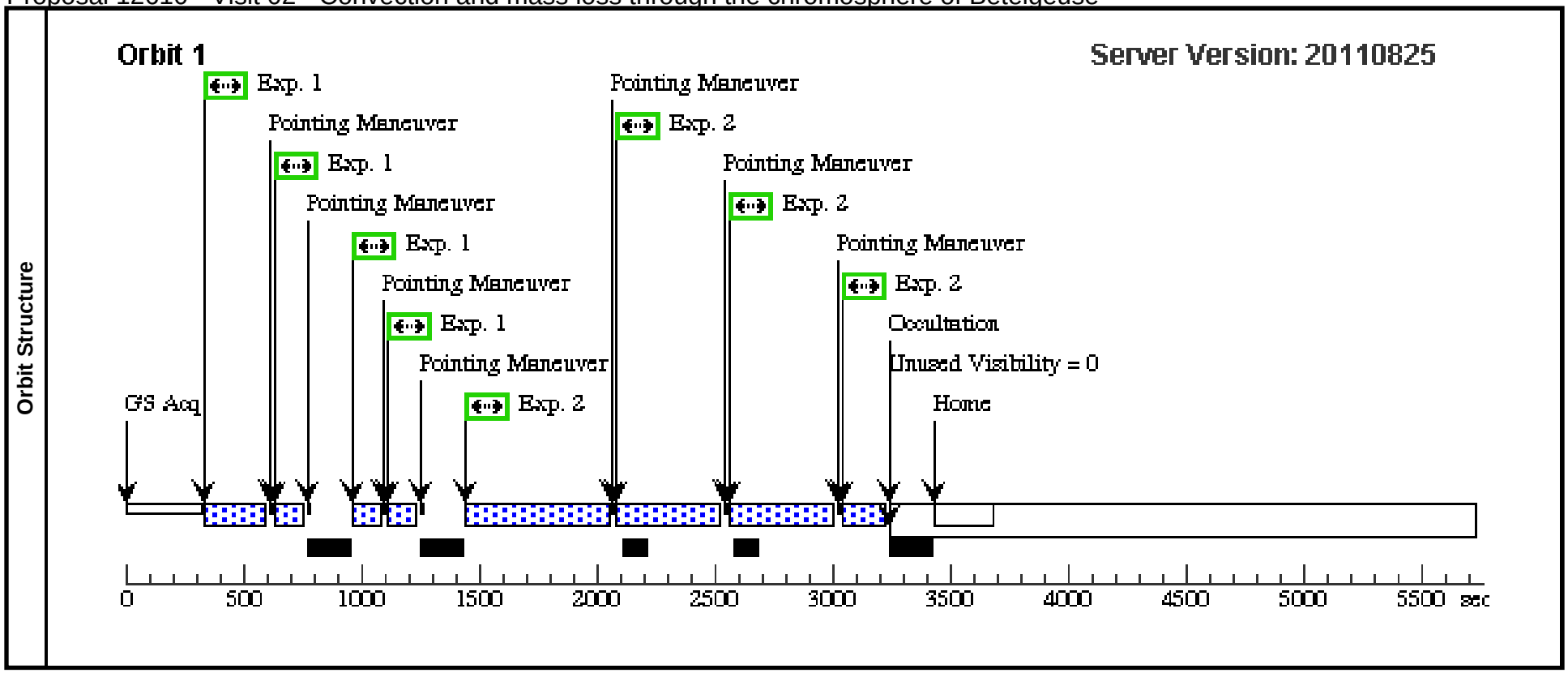
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Bet-FUV-F25NDQ2 (185986)	(1) BETELGEUSE	STIS/FUV-MAMA, ACCUM, F25NDQ2	MIRROR			Pattern 1, Exps 1-1 in Visit 02 (1)	110 Secs	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	

Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is split in four sub-exposures to allow dithering with an amplitude of 1.5 pixels.

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
2	Bet-NUV-F25ND5 (185985)	(1) BETELGEUSE	STIS/NUV-MAMA, ACCUM, F25ND5	MIRROR			Pattern 1, Exps 2-2 in Visit 02 (1)	430 Secs	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	
								[==>169.0 Secs (Pattern 4)]	

Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is split in four sub-exposures to allow dithering with an amplitude of 1.5 pixels.


Orbit Structure
Orbit 1
Server Version: 20110825
GS Acq
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Occultation
Unused Visibility = 0
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 12610, Visit 03, implementation Thu Jan 05 02:12:17 GMT 2012

Diagnostic Status: No Diagnostics

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

Special Requirements: AFTER 01 BY 300 D TO 430 D

Comments: This is a three-filter exposure on Betelgeuse (FUV-F25LYA, FUV-F25NDQ2, NUV-F25ND5), spread over 2 orbits.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=STIS-MAMA-BOX	Coordinate Frame=POS-TARG		(2), (3)
	Purpose=DITHER	Pattern Orientation=26.6		
	Number Of Points=4	Angle Between Sides=143.130102		
	Point Spacing=0.0369	Center Pattern=false		
	Line Spacing=0.0369			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	BETELGEUSE	RA: 05 55 10.3053 (88.7929388d)	Proper Motion RA: 27.54 mas/yr	V=0.7+/-0.5	Reference Frame: ICRS
	Alt Name1: ALPHA-ORI	Dec: +07 24 25.43 (7.40706d)	Proper Motion Dec: 11.30 mas/yr	magU = 4.38,	
	Alt Name2: HD39801	Equinox: J2000	Parallax: 0.00655"	magB = 2.27,	
			Epoch of Position: 2000	E(B-V)=0.4699	
			Radial Velocity: 21.91 km/sec		

Comments: Betelgeuse is an irregular, moderately variable star. Its current (Dec 2011) V band magnitude according to the AAVSO, is mV=0.45, i.e. slightly above its average brightness over the last 10 years (mV ~0.5, with an evolution range between 0.3 and 1.0).

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Bet-FUV-F25LYA (185981)	(1) BETELGEUSE	STIS/FUV-MAMA, TIME-TAG, F25LYA	MIRROR	BUFFER-TIME=4000			2800 Secs *[==>2751.0 Secs]*	 ***[1]***

Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is similar to a STIS-MAMA F25LYA exposure in TIME-TAG mode (EXPTIME=2300s) obtained on 2000-03-14 on Betelgeuse with STIS in the same configuration (exposure id: o55001d7q), that gave a maximum flux of 200 counts/s on the star, and a total flux of 1450 counts/s on the MAMA array. This figure is comparable to out result using the STIS imaging ETC (1870 counts/s).
The corresponding BUFFER-TIME parameter is therefore 2e6/1870 = 1070 s. With a further safety margin of 20%, we obtain a BUFFER-TIME value of 855 s.

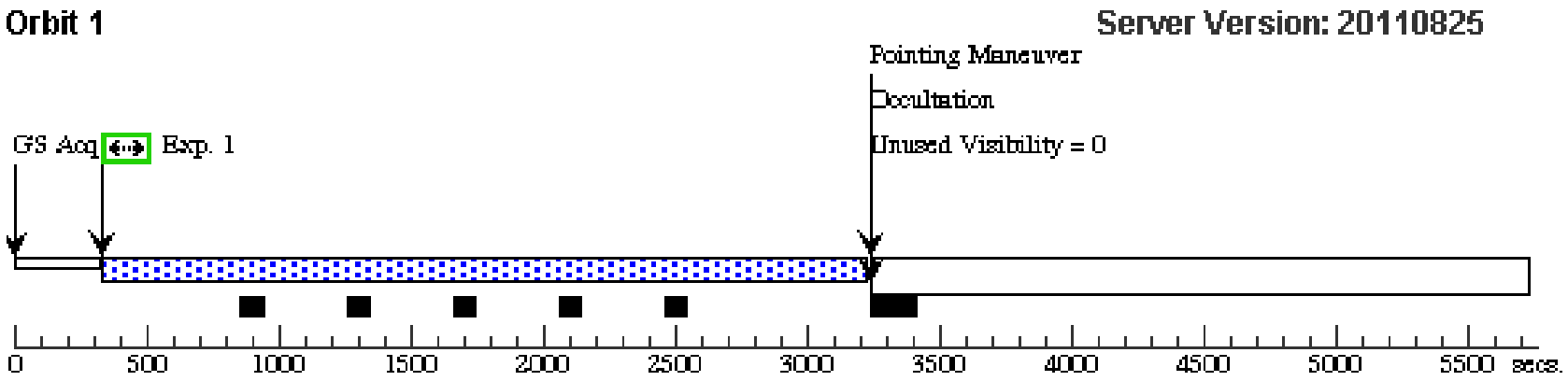
2	Bet-FUV-F25NDQ2 (185983)	(1) BETELGEUSE	STIS/FUV-MAMA, ACCUM, F25NDQ2	MIRROR			Pattern 1, Exps 2-2 in Visit 03 (1)	120 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	 ***[2]***

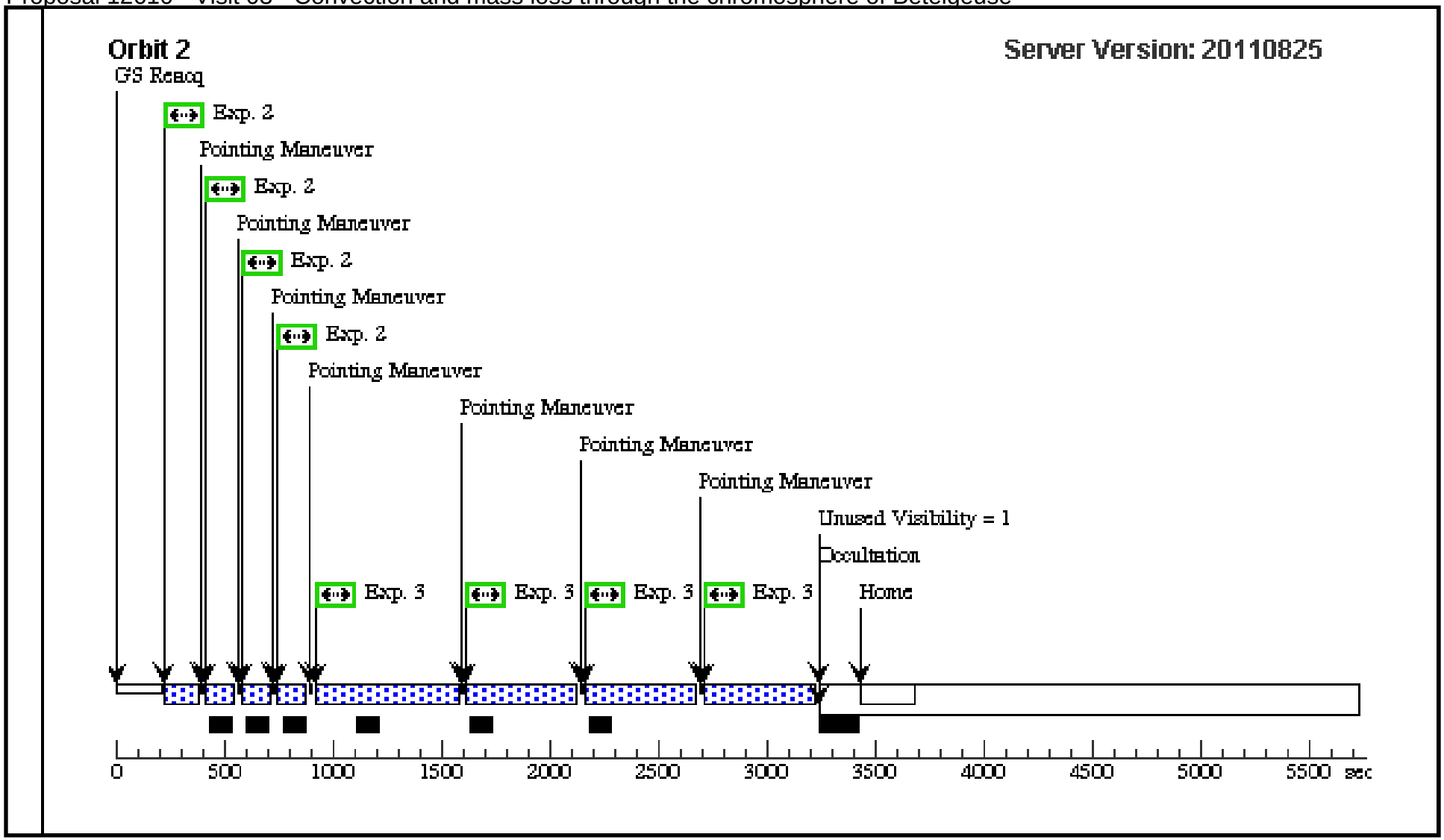
Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is split in four sub-exposures to allow dithering with an amplitude of 1.5 pixels.

3	Bet-NUV-F25ND5 (185984)	(1) BETELGEUSE	STIS/NUV-MAMA, ACCUM, F25ND5	MIRROR			Pattern 1, Exps 3-3 in Visit 03 (1)	500 Secs *[==>479.0 Secs (Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	 ***[2]***

Comments: For the ETC computation, we assembled a spectrum of Betelgeuse from past STIS observations using the E140M and E230M settings.
This exposure is split in four sub-exposures to allow dithering with an amplitude of 1.5 pixels.

Orbit Structure




Orbit 2
Server Version: 20110825
GS Reacq
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 1
Occultation
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 12610, Visit 04, implementation Thu Jan 05 02:12:17 GMT 2012

Diagnostic Status: No Diagnostics

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

Special Requirements: (none)

Comments: Three-filter exposure on the PSF calibrator HD 38393, 1 orbit.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=STIS-MAMA-BOX	Coordinate Frame=POS-TARG		(2), (3)
	Purpose=DITHER	Pattern Orientation=26.6		
	Number Of Points=4	Angle Between Sides=143.130102		
	Point Spacing=0.0369	Center Pattern=false		
	Line Spacing=0.0369			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	HD38393	RA: 05 44 27.7909 (86.1157954d)	Proper Motion RA: -291.67 mas/yr	V=3.6	Reference Frame: ICRS
	Alt Name1: GAMMA-LEP	Dec: -22 26 54.18 (-22.44838d)	Proper Motion Dec: -368.97 mas/yr	magU=4.08,	
	Alt Name2: HR1983	Equinox: J2000	Parallax: 0.11202"	magB=4.07	
			Epoch of Position: 2000		
			Radial Velocity: -9.7 km/sec		

Comments: This star (Gamma Lep) is a PSF calibrator.

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	PSF-FUV-F25LYA (185989)	(2) HD38393	STIS/FUV-MAMA, TIME-TAG, F25LYA	MIRROR	BUFFER-TIME=400			200 Secs *[==>894.0 Secs]*	 ***[1]***

Comments: This exposure is similar to a STIS-MAMA F25LYA exposure in TIME-TAG mode (EXPTIME=2300s) obtained on 2000-03-14 on HD38393 with STIS in the same configuration (exposure id: o55003dhq), that gave a maximum flux of 1867 counts in central pixel on the star.
For the ETC computation, we assembled a flux-calibrated spectrum of HD38393 from archival IUE spectra. The STIS ETC gives a total count rate on the detector of 1990 counts/s, which is comparable to the observed total count rate of 1960 counts/s in the o55003dhq exposure.
We rely on this 2000 counts/s figure, with a safety margin of 20% to estimate the corresponding BUFFER-TIME parameter a being 800 s.

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
2	PSF-FUV-F25NDQ2 (185991)	(2) HD38393	STIS/FUV-MAMA, ACCUM, F25NDQ2	MIRROR			Pattern 1, Exps 2-2 in Visit 04 (1)	40 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	 ***[1]***

Comments: For the ETC computation, we assembled a flux-calibrated spectrum of HD38393 from archival IUE spectra.

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
3	PSF-NUV-F25ND5 (185992)	(2) HD38393	STIS/NUV-MAMA, ACCUM, F25ND5	MIRROR			Pattern 1, Exps 3-3 in Visit 04 (1)	110 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>133.0 Secs (Pattern 4)]*	 ***[1]***

Comments: For the ETC computation, we assembled a flux-calibrated spectrum of HD38393 from archival IUE spectra.

Orbit Structure