



13710 - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Cycle: 22, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

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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) M-31-CENTER-SBC-1	ACS/SBC WFC3/UVIS	2	04-Mar-2015 21:03:58.0	yes
02	(2) M-31-CENTER-SBC-2	ACS/SBC WFC3/UVIS	2	04-Mar-2015 21:04:00.0	yes

<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>
03	(4) M-31-CENTER-SBC-3	ACS/SBC WFC3/UVIS	2	04-Mar-2015 21:04:02.0	yes
04	(3) M-31-CENTER-UVIS	ACS/WFC WFC3/UVIS	4	04-Mar-2015 21:04:06.0	yes

10 Total Orbits Used

ABSTRACT

We aim to use HST observations of M31 to generate the definitive data set for modeling the population of the UV-bright stars that contribute to the UV flux in old stellar populations (i.e., the "UV excess" seen in some elliptical galaxies and spiral bulges).

We propose to place stringent observational constraints on the post-AGB (P-AGB) and post-early AGB (PE-AGB) phases of stellar evolution using a UV survey of M31's bulge. M31 is a critical laboratory for testing these models, as it hosts an old, metal-rich stellar population with high stellar densities such that even rare evolutionary phases are well-represented.

We will (1) assemble a catalog of UV-bright stars in the center of M31 in F336W and F225W, extending out to ~ 0.7 kpc, to sample stellar populations with different metallicities; and (2) image a smaller 0.9 sq-arcmin strip with ACS/SBC in F140LP, to image the regions with the highest density of rapidly-evolving P-AGB stars. The FUV imaging will allow us to separate the P-AGB from the PE-AGB. These observations will include thousands of UV-bright stars, increasing the size of existing samples by orders of magnitude.

These new observations will drive revisions in models for post-HB evolution, which we will merge into new isochrone libraries and stellar population synthesis codes. The revisions will have important implications for AGB evolution, spectral evolution models of galaxies, and for mass loss on the RGB. The observations will also have a direct impact on interpreting (1) the UV flux from old stellar populations; (2) the emission line flux from M31's nuclear spiral; and (3) models of dust heating by old stellar populations.

OBSERVING DESCRIPTION

Overview: Our observations consist of (1) 1 F225W+F336W WFC3/UVIS pointing oriented along the minor axis of the M31 bulge to get significantly better temperature sensitivity and depth than existing data; (2) 2 F140LP pointings (3200 arcsec^2) in the central region, where the

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density of the P-AGB stars are highest, to get optimal constraints on the hottest, rarest stars; (3) a third F225W+F336W WFC3/UVIS image, carried out in parallel with the primary SBC mosaic, to get additional area and better sampling of M31's radial metallicity and abundance gradient; (4) F502N, F658N, F555W, F625W ACS/WFC images taken in parallel with the primary WFC3/UVIS pointing to identify PNe, which will be used to calibrate PNe selection in the PHAT filter set, giving us more leverage on their separation from post-EHB stars in the bulge.

Tiling Strategy: To sample the metallicity/abundance gradient in M31's bulge, we require 1 UVIS pointing. The primary pointing over the M31 center covers out to $r \sim 0.5$ kpc, comparable to where the UV-bright population gradient was identified in brighter PHAT data. For the SBC F140LP observations, we would ideally tile the whole area covered by the UVIS tiles. However, such a tiling is not feasible, given the SBC's smaller FOV. Moreover, given the rapid fall-off in the P-AGB population seen in the PHAT F275W data (see Rosenfield et al., 2012), observations far from the center become increasingly inefficient. We therefore select a minimal set of 3 tiles arranged and sample the high density P-AGB regions (~ 0.27 kpc). Based on the PHAT F275W data, it is not possible to avoid the small sparse dust lanes found in M31's bulge. However, the dust features are extremely narrow and well-localized such that they can be excluded from our analysis. In addition, we will use the extinction measurements from Dong et al., 2014 who also identified and characterized 5 dusty clumps near the nucleus of M31. The second UVIS region comes essentially free as a parallel and samples $r \sim 1$ kpc. Orientations were chosen to maximize schedulability and to arrange parallels to overlap each other and existing multiwavelength data from PHAT. A test Phase II proposal including these constraints demonstrates that the 6 orbits of far-UV imaging (plus parallels) has 96 days per year of availability, while the 4 orbits of near-UV imaging has 61 days of availability.

Filter Choices: With a target color error of ~ 0.05 mag, we calculate excellent temperature sensitivity for $T_{\text{eff}} < 32,000\text{K}$ in F225W-F336W and for $T_{\text{eff}} < 80,000\text{K}$ in F140LP-F336W; the former is adequate for constraining models of PE-AGB and AGBM stars, and for brighter P-AGB stars, and the latter is necessary to track P-AGB evolution fainter than F336W ~ 24 , where it would otherwise be blended with other evolutionary phases (i.e., PE-AGB, AGBM). We chose F140LP over other SBC filters to block strong airglow lines (Ly-alpha and O I) while retaining sufficient throughput. The target photometric error is roughly equivalent to STScI ETC's Optimal SNR ~ 20 for PSF photometry. We set the exposure time to reach this SNR at F140LP=24.8, F225W=25.1, and F336W=26.3 (while these are the formal optimal SNR we expect, in practice the EHB crowding in the bulge will shift our limiting magnitudes slightly fainter; these depths are chosen to reveal the evolutionary phases of interest in each color-combination, while still being bright enough to avoid crowding from fainter, more numerous HB stars. The required exposure times can be reached in 4 orbits for the UVIS pointing (3 orbits for F225W and 1 orbit for F336W which we will co-add with the archival PHAT data) and 2 orbits for each of the two SBC pointings.

Brown's previous FOC far-UV imaging found only 52 stars brighter than 23 VEGAMAG in a $14 \times 14''$ region that included the M31 center.

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Extrapolating from the PHAT data, we estimate we will obtain SNR=10 photometry of thousands of sources above F140LP=23.6 and F225W=24.0, including all PE-AGB and P-AGB stars above 10,000K and the brightest AGBM stars as well as ~10,000 UV-bright stars in our F225W+F336W images.

Need for HST: HST is required for this project. The high stellar densities of M31's bulge cannot be resolved in the UV from the ground, likewise, the F225W and F140LP wavelengths can only be reliably detected from space.

Parallels: We will use WFC3/UVIS in parallel with the primary ACS/SBC observations, using identical filters as the primary UVIS exposures; these parallels will give us additional areal and radial coverage. When running WFC3/UVIS in primary, we will use ACS to optimize the selection and analysis of PNe throughout the PHAT imaging area, giving us additional leverage on post-AGB evolution in the bulge of M31. To do this, we will carry out narrow band imaging of [OIII]5007 AA (F502N), H α (F658N; to discriminate from HII regions) and the corresponding continuum (F555W, F625W). While PHAT has coverage in F475W and F814W, adding F625W and F555W will sample the continuum at 2 intermediate points with high S/N. Any stellar continuum can be well modeled with these 4 points.

Ancillary Science: In addition to our primary science goals, our observations will be extremely useful for further studies of M31's young nuclear cluster (Lauer et al., 2012), the contribution of old UV bright stars to dust heating (known to be unusual in M31's center), the possible ionization of the ISM by P-AGB and PE-AGB populations (which can potentially be confused with LINER emission from AGN), and possibly using the UV-upturn as an age indicator for elliptical galaxies (Dorman et al., 1995; Bressan et al., 1994)

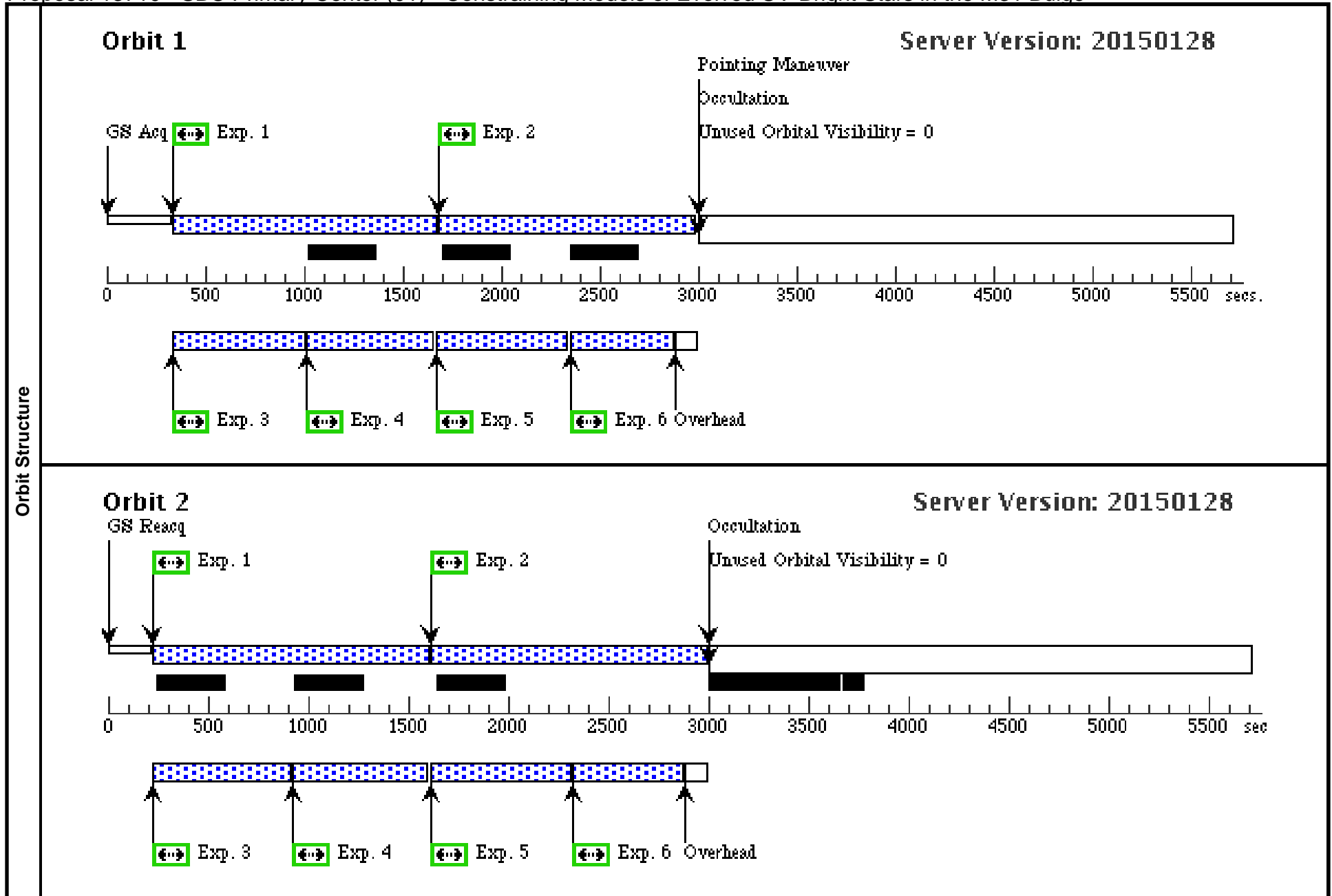
Proposal 13710 - SBC Primary Center (01) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Thu Mar 05 02:04:08 GMT 2015

Visit	Proposal 13710, SBC Primary Center (01), completed Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS, ACS/SBC Special Requirements: SCHED 100%; ORIENT 69D TO 71 D					
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures	
	(1)	Pattern Type=ACS-SBC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.472 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=44.4 Angle Between Sides= Center Pattern=false		(1-6)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	M-31-CENTER-SBC-1	RA: 00 42 45.4108 (10.6892117d) Dec: +41 16 41.50 (41.27819d) Equinox: J2000		V=3.44	Reference Frame: ICRS
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					

Proposal 13710 - SBC Primary Center (01) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit	
	1	(ACS.im.36 6351)	(1) M-31-CENTER- SBC-1	ACS/SBC, ACCUM, SBC	F140LP				Pattern 1, Exps 1-6 in SBC Primary Center (01) (1)	1200 Secs (2626 Secs)	
										[==>1275.0 Secs (Pattern 1)]	[1]
	2	(ACS.im.36 6351)	(1) M-31-CENTER- SBC-1	ACS/SBC, ACCUM, SBC	F140LP				Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary Center (01)	[==>1351.0 Secs (Pattern 2)]	[2]
	3		(1) M-31-CENTER- SBC-1	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Pattern 1, Exps 1-6 in SBC Primary Center (01) (1)	1200 Secs (1067 Secs)	
										[==>518.0 Secs (Pattern 1)]	[1]
4		(1) M-31-CENTER- SBC-1	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary Center (01)	[==>549.0 Secs (Pattern 2)]	[2]	
5		(1) M-31-CENTER- SBC-1	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W	FLASH=12			Pattern 1, Exps 1-6 in SBC Primary Center (01) (1)	1200 Secs (1067 Secs)		
									[==>518.0 Secs (Pattern 1)]	[1]	
6		(1) M-31-CENTER- SBC-1	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W	FLASH=12			Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary Center (01)	[==>549.0 Secs (Pattern 2)]	[2]	



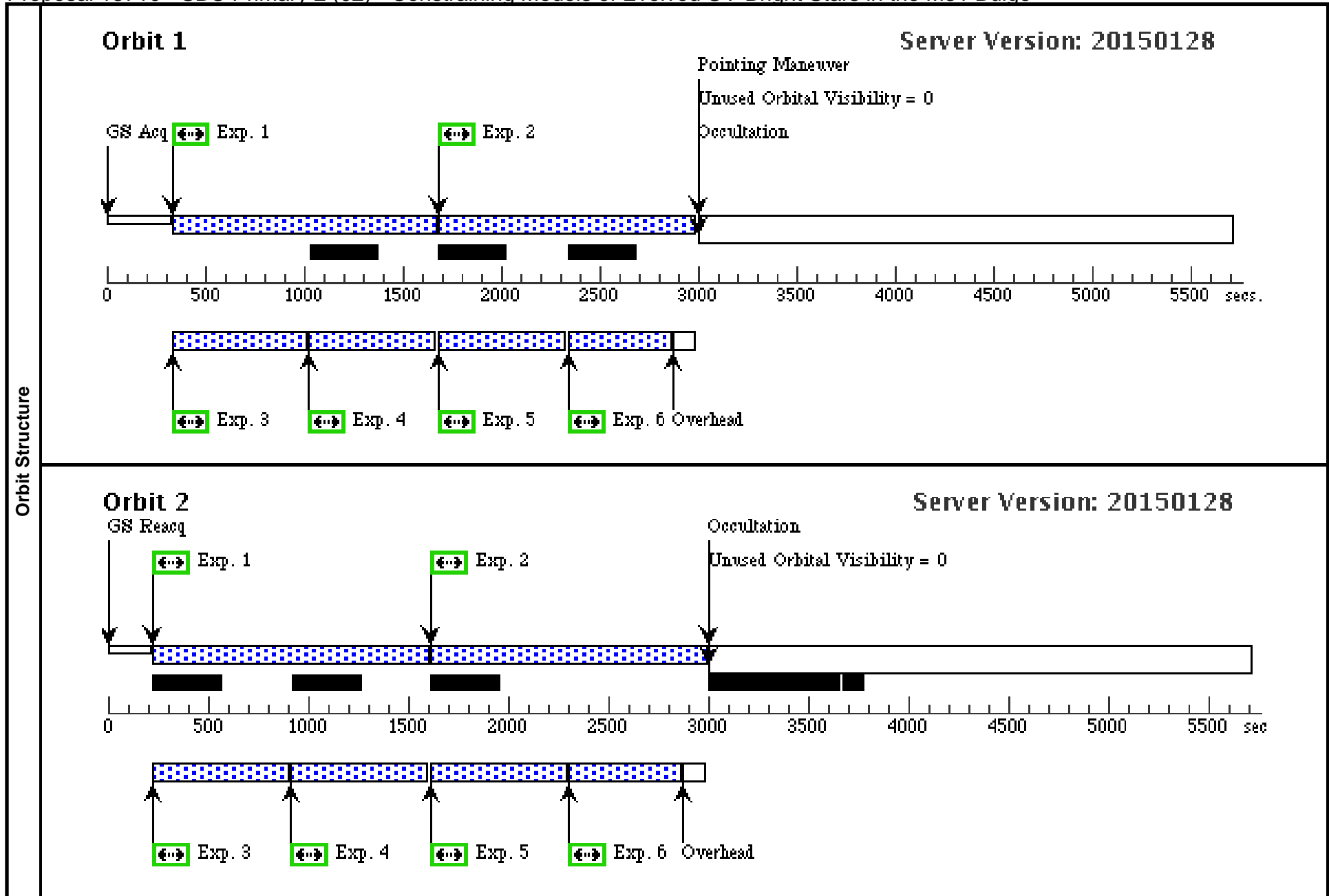
Proposal 13710 - SBC Primary 2 (02) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Thu Mar 05 02:04:09 GMT 2015

Visit	Proposal 13710, SBC Primary 2 (02), completed Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS, ACS/SBC Special Requirements: SCHED 100%; SAME ORIENT AS 01					
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures	
	(1)	Pattern Type=ACS-SBC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.472 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=44.4 Angle Between Sides= Center Pattern=false		(1-6)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(2)	M-31-CENTER-SBC-2	RA: 00 42 47.6094 (10.6983725d) Dec: +41 17 4.62 (41.28462d) Equinox: J2000		V=3.44	Reference Frame: ICRS
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					

Proposal 13710 - SBC Primary 2 (02) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit	
	1	(ACS.im.36 6351)	(2) M-31-CENTER- SBC-2	ACS/SBC, ACCUM, SBC	F140LP				Pattern 1, Exps 1-6 in SBC Primary 2 (02) (1)	1200 Secs (2626 Secs)	
										[==>1275.0 Secs (Pattern 1)]	[1]
	2	(ACS.im.36 6351)	(2) M-31-CENTER- SBC-2	ACS/SBC, ACCUM, SBC	F140LP				Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary 2 (02)	[==>1351.0 Secs (Pattern 2)]	[2]
	3		(2) M-31-CENTER- SBC-2	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Pattern 1, Exps 1-6 in SBC Primary 2 (02) (1)	1200 Secs (1084 Secs)	
										[==>524.0 Secs (Pattern 1)]	[1]
4		(2) M-31-CENTER- SBC-2	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary 2 (02)	[==>560.0 Secs (Pattern 2)]	[2]	
5		(2) M-31-CENTER- SBC-2	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Pattern 1, Exps 1-6 in SBC Primary 2 (02) (1)	1200 Secs (1084 Secs)		
									[==>524.0 Secs (Pattern 1)]	[1]	
6		(2) M-31-CENTER- SBC-2	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary 2 (02)	[==>560.0 Secs (Pattern 2)]	[2]	



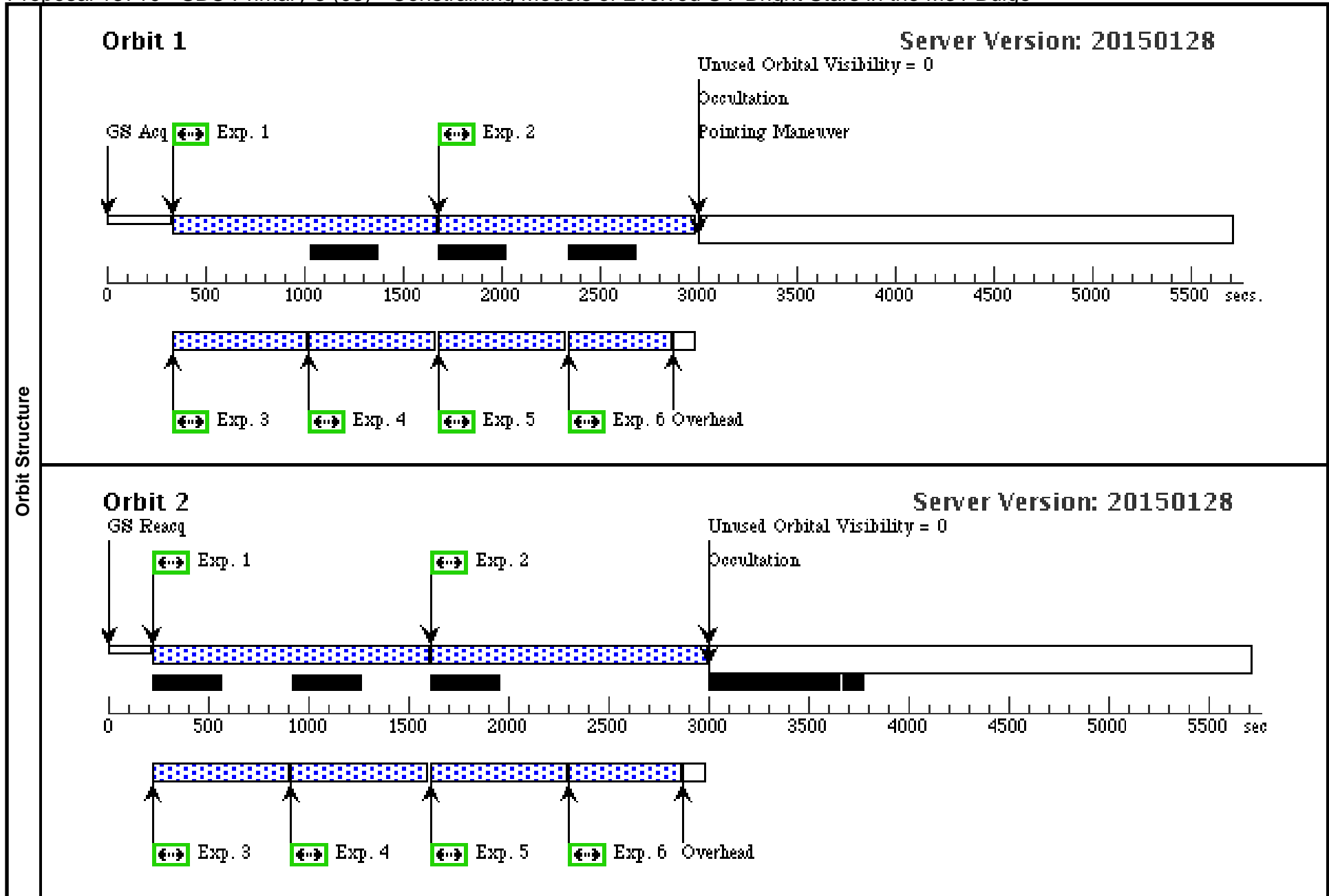
Proposal 13710 - SBC Primary 3 (03) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Thu Mar 05 02:04:09 GMT 2015

Visit	Proposal 13710, SBC Primary 3 (03), completed Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS, ACS/SBC Special Requirements: SCHED 100%; SAME ORIENT AS 01					
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures	
	(1)	Pattern Type=ACS-SBC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.472 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=44.4 Angle Between Sides= Center Pattern=false		(1-6)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(4)	M-31-CENTER-SBC-3	RA: 00 42 49.7046 (10.7071025d) Dec: +41 17 31.77 (41.29216d) Equinox: J2000		V=3.44	Reference Frame: ICRS
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					

Proposal 13710 - SBC Primary 3 (03) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit	
	1	(ACS.im.36 6351)	(4) M-31-CENTER- SBC-3	ACS/SBC, ACCUM, SBC	F140LP				Pattern 1, Exps 1-6 in SBC Primary 3 (03) (1)	1200 Secs (2626 Secs)	
										[==>1275.0 Secs (Pattern 1)]	[1]
	2	(ACS.im.36 6351)	(4) M-31-CENTER- SBC-3	ACS/SBC, ACCUM, SBC	F140LP				Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary 3 (03)	[==>1351.0 Secs (Pattern 2)]	[2]
	3		(4) M-31-CENTER- SBC-3	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Pattern 1, Exps 1-6 in SBC Primary 3 (03) (1)	1200 Secs (1084 Secs)	
										[==>524.0 Secs (Pattern 1)]	[1]
4		(4) M-31-CENTER- SBC-3	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary 3 (03)	[==>560.0 Secs (Pattern 2)]	[2]	
5		(4) M-31-CENTER- SBC-3	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Pattern 1, Exps 1-6 in SBC Primary 3 (03) (1)	1200 Secs (1084 Secs)		
									[==>524.0 Secs (Pattern 1)]	[1]	
6		(4) M-31-CENTER- SBC-3	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12			Prime + Parallel Group 1-6 in Pattern 1, Exps 1-6 in SBC Primary 3 (03)	[==>560.0 Secs (Pattern 2)]	[2]	



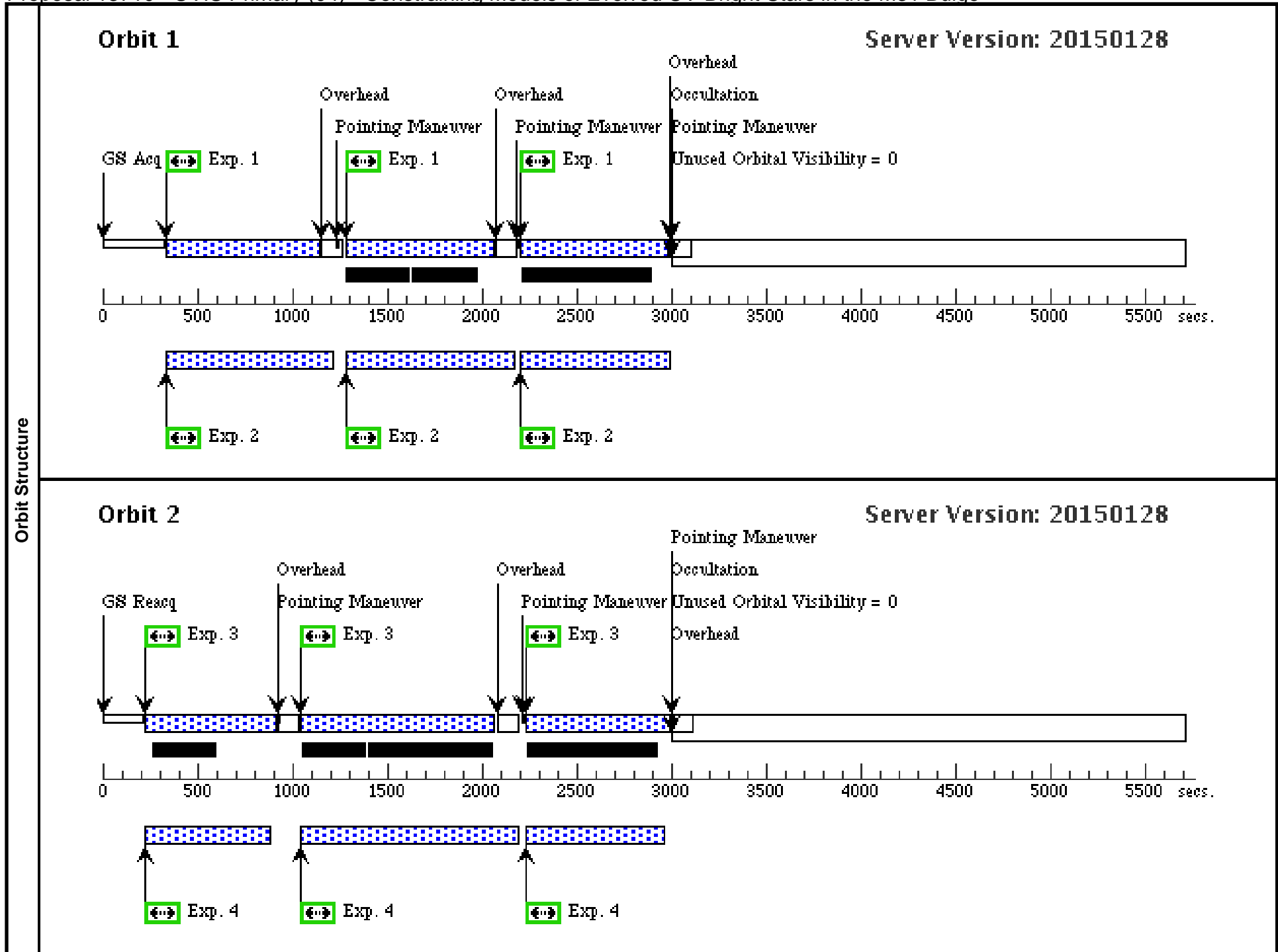
Proposal 13710 - UVIS Primary (04) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

Thu Mar 05 02:04:09 GMT 2015

Visit	Proposal 13710, UVIS Primary (04), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS, ACS/WFC Special Requirements: SCHED 100%; ORIENT 219D TO 238 D					
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures	
	(2)	Pattern Type=WFC3-UVIS-DITHER- LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1-2), (3-4), (5-6), (7-8)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(3)	M-31-CENTER-UVIS	RA: 00 42 50.7112 (10.7112967d) Dec: +41 16 47.81 (41.27995d) Equinox: J2000		V=3.44	Reference Frame: ICRS
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					

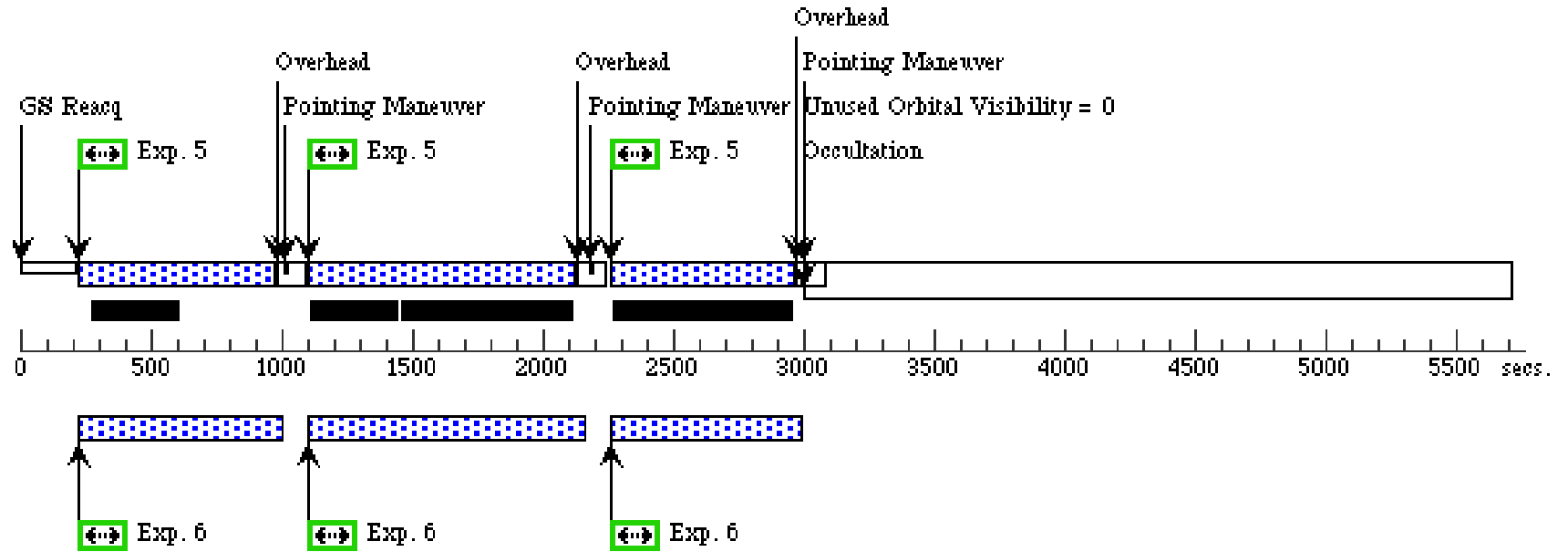
Proposal 13710 - UVIS Primary (04) - Constraining Models of Evolved UV-Bright Stars in the M31 Bulge

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit	
Exposures	1	(ACS.im.36 6351)	(3) M-31-CENTER-UVIS	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12	POS TARG 0.08,0.08	Pattern 2, Exps 1-2 in UVIS Primary (04) (2) Prime + Parallel Group 1-2 in Pattern 2, Exps 1-2 in UVIS Primary (04)	710 Secs (2340 Secs) [==>780.0 Secs (Pattern 1)] [==>780.0 Secs (Pattern 2)] [==>780.0 Secs (Pattern 3)]	[1]
	2		(3) M-31-CENTER-UVIS	ACS/WFC, ACCUM, WFCENTER	F625W			Pattern 2, Exps 1-2 in UVIS Primary (04) (2) Prime + Parallel Group 1-2 in Pattern 2, Exps 1-2 in UVIS Primary (04)	664 Secs (2105 Secs) [==>677.0 Secs (Pattern 1)] [==>764.0 Secs (Pattern 2)] [==>664.0 Secs (Pattern 3)]	[1]
	3	(ACS.im.36 6351)	(3) M-31-CENTER-UVIS	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12	POS TARG 0.08,-0.08	Pattern 2, Exps 3-4 in UVIS Primary (04) (2) Prime + Parallel Group 3-4 in Pattern 2, Exps 3-4 in UVIS Primary (04)	1200 Secs (2472 Secs) [==>692.0 Secs (Pattern 1)] [==>1020.0 Secs (Pattern 2)] [==>760.0 Secs (Pattern 3)]	[2]
	4		(3) M-31-CENTER-UVIS	ACS/WFC, ACCUM, WFCENTER	F658N	FLASH=12		Pattern 2, Exps 3-4 in UVIS Primary (04) (2) Prime + Parallel Group 3-4 in Pattern 2, Exps 3-4 in UVIS Primary (04)	1200 Secs (2120 Secs) [==>500.0 Secs (Pattern 1)] [==>1020.0 Secs (Pattern 2)] [==>600.0 Secs (Pattern 3)]	[2]
	5		(3) M-31-CENTER-UVIS	WFC3/UVIS, ACCUM, UVIS-CENTER	F225W	FLASH=12	POS TARG -0.08,-0.08	Pattern 2, Exps 5-6 in UVIS Primary (04) (2) Prime + Parallel Group 5-6 in Pattern 2, Exps 5-6 in UVIS Primary (04)	700 Secs (2469 Secs) [==>749.0 Secs (Pattern 1)] [==>1020 Secs (Pattern 2)] [==>700.0 Secs (Pattern 3)]	[3]
	6		(3) M-31-CENTER-UVIS	ACS/WFC, ACCUM, WFCENTER	F550M	FLASH=12		Pattern 2, Exps 5-6 in UVIS Primary (04) (2) Prime + Parallel Group 5-6 in Pattern 2, Exps 5-6 in UVIS Primary (04)	700 Secs (2151 Secs) [==>615.0 Secs (Pattern 1)] [==>936.0 Secs (Pattern 2)] [==>600 Secs (Pattern 3)]	[3]
	7		(3) M-31-CENTER-UVIS	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W	FLASH=12	POS TARG -0.08,0.08	Pattern 2, Exps 7-8 in UVIS Primary (04) (2) Prime + Parallel Group 7-8 in Pattern 2, Exps 7-8 in UVIS Primary (04)	700 Secs (2276 Secs) [==>656.0 Secs (Pattern 1)] [==>1020.0 Secs (Pattern 2)] [==>600.0 Secs (Pattern 3)]	[4]
	8		(3) M-31-CENTER-UVIS	ACS/WFC, ACCUM, WFCENTER	F502N	FLASH=12		Pattern 2, Exps 7-8 in UVIS Primary (04) (2) Prime + Parallel Group 7-8 in Pattern 2, Exps 7-8 in UVIS Primary (04)	700 Secs (2276 Secs) [==>656.0 Secs (Pattern 1)] [==>1020.0 Secs (Pattern 2)] [==>600.0 Secs (Pattern 3)]	[4]



Orbit 3

Server Version: 20150128



Orbit 4

