



# 13821 - H-alpha Filaments and Feedback in NGC4696 at the centre of the Centaurus cluster

Cycle: 22, Proposal Category: GO

(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) NGC-4696	WFC3/UVIS	5	14-Oct-2014 21:05:31.0	yes
02	(1) NGC-4696	WFC3/UVIS	3	14-Oct-2014 21:05:35.0	yes
03	(1) NGC-4696	WFC3/UVIS	5	14-Oct-2014 21:05:39.0	yes

13 Total Orbits Used

### **ABSTRACT**

One third of Brightest Cluster Galaxies (BCG) have strong optical emission lines originating in an extensive filamentary nebula. The prototype is the spectacular nebula around NGC1275 in the Perseus cluster which we are have imaged in H-alpha and [NII] with HST, spatially resolving the filamentary structure. Here we propose deep observations of the nebula in NGC4696, the BCG in the Centaurus cluster. NGC4696, at approximately half the distance of NGC1275 is the nearest BCG nebula with molecular filaments, thus affording the highest linear spatial resolution in this type of source.

These observations will test the magnetic support model for the filaments by resolving and measuring the width of the filaments, and test the particle heating model for the excitation of the filaments through measurement of their surface brightness distribution and morphology.

The relation of the filaments to the dust lanes, and the complex Faraday Rotation maps of this source will provide further diagnostics not available in NGC1275. The results will have a wide relevance to similar nebulae found around distant radio galaxies and young galaxies.

## OBSERVING DESCRIPTION

We propose to image the BCG (NGC~4696) in the Centaurus cluster in H $\alpha$ + [NII] with WFC3/UVIS and the F665N narrow band filter. HST is required for this project in order to obtain the high spatial resolution. WFC3 has a comprehensive filter set well matched for the H $\alpha$  imaging.

NGC~4696 ground-based imaging (Crawford et al 2005), with seeing of about one arcsec, shows a bright extended filament 22 arcsec to the South East of the nucleus with an (observed) H $\alpha$  surface brightness of  $\sim 1 \times 10^{-16} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ arcsec}^{-2}$  (the value quoted in the paper is  $1.4 \times 10^{-16} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ arcsec}^{-2}$  after correction for Galactic reddening by a factor of 33%). In this proposal we aim to construct a good map with a signal-to-noise ratio of  $\sim 10$  per  $2 \times 2$  pixel resolution element down to one third of this surface brightness.

Our NGC~1275 HST data (Fig.~1b,c) show detailed structures down to 0.1-0.2 arcsec scales, indicating that the intrinsic surface brightness is much higher than observed in the ground-based data. Assuming the filaments have a spatial size of 0.3 arcsec would imply that their surface brightness is  $\sim 10$  times higher than observed in the ground-based optical data. We note also that in NGC~4696 the NII $\lambda$ 6584 line is twice as bright as H $\alpha$ , and that this will also be transmitted by our selected narrow-band filter.

We model the extended emission (using the WFC3 ETC) as arising from

two emission lines ( $H\alpha$  and  $[NII]\lambda 6584$ ) of surface brightness  $3$  and  $6 \times 10^{-16} \text{ erg cm}^{-2} \text{ arcsec}^{-2}$  (a line width of  $200 \text{ km/s}$  is used) plus an underlying elliptical galaxy continuum. The normalization for the galaxy taken from the work of Schombert (1987) shows that the surface brightness of NGC4696 is  $21 \text{ Vmag arcsec}^{-2}$  at a radial distance of  $28 \text{ arcsec}$  from the nucleus, appropriate to the fainter outermost filaments. However, more modern references suggest  $R \sim 21$  at this radius (Penereiro et al 1994; Sparks et al 1989).

For the simulation we use a Galactic extinction value normalized to  $E(B-V)=0.12 \text{ mag}$ , standard background values and choose a 4-point box dither pattern for the full orbit exposures and a 3-point line dither pattern for the half-orbit exposures.

The APT indicates that after overheads there is time for  $\sim 2700 \text{ s}$  of on-source exposure on NGC~4696 in a single orbit after spacecraft and instrument overheads are taken into account.

We require an off-band image in a line-free spectral region to enable the galaxy continuum to be subtracted. This can be obtained efficiently using the F814W filter for NGC~4696.

A further image, taken in a bluer continuum band, will allow dust extinction maps to be made and any young star clusters to be seen. The F467M filter is ideal, as it transmits a relatively blue and, crucially, emission-line free part of the spectrum with good system throughput.

In Table 1 we provide a summary of the target, its properties, selected filters, exposure times and the expected signal-to-noise ratio based on ETC calculations. A major contributor to background

counts (and hence noise) in the emission line image (F665N) is the underlying galaxy. This is included in the ETC calculation with the surface brightness given in column 6. We assumed each full orbit to be split into four exposures by a 4-point box dither and calculated signal-to-noise ratios for a 2x2 pixel (0.08x0.08 arcsec) spatial region. Half-orbit exposures use the 3-point line dither.

Although the underlying galaxy emission gives sufficient counts to ensure good charge transfer near the centre of the galaxy, near the outermost visible filaments, this is not the case. We therefore choose to post-flash the chip to ensure a minimum of 12e- even far away from the galaxy to enable possible detection of very remote filaments. The required post-flash was included in the ETC calculations.

A total 10.5 orbits will give us a signal-to-noise ratio of 8.6 in the narrow-band F665N filter in a 2x2 pixel resolution element.

A further 0.5 orbit in the broad-band F814W filter will give a signal-to-noise ratio of 25.9 (in the same spatial region), sufficient to subtract the underlying galaxy without significantly degrading the signal-to-noise ratio of the narrow-band observations. Two orbits of exposure taken with the F467M filter will allow a signal-to-noise ratio of 8.3 to be reached.

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\begin{table}
\centerline{Table 1. Proposed observations}
\begin{tabular}{lcccccccc}
\hline
Target & Redshift & Band & Line SB & E{B-V} & Gal & Inst & Filter & Exp & S/N \\
\hline
NGC~4696 & 0.00987 & H $\alpha$ + [NII] & 3,6e-16 & 0.12 &  $\mu_R=21.0$  & WFC3 & F665N & 10.5 & 8.6 \\
NGC~4696 & 0.00987 & Red cont & - & 0.12 &  $\mu_V=21.0$  & WFC3 & F814W & 0.5 & 25.9

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NGC~4696 & 0.00987 & Blue cont & - & 0.12 &  $\mu_R=21.0$  & WFC3 & F467M & 2.0 & 8.3 \\

\hline

\end{tabular}

%\caption[] {Targets and proposed observations.}

Column 4 gives the line surface brightnesses in  $\text{erg s}^{-1} \text{cm}^{-2} \text{arcsec}^{-2}$  of H $\alpha$  and [NII] $\lambda$  6584.

Column 6 gives the galaxy continuum surface brightness in  $\text{mags arcsec}^{-2}$ .

Column 9 gives the exposure time in orbits to reach the signal-to-noise ratio given in column 10

in a 2x2 pixel spatial region.

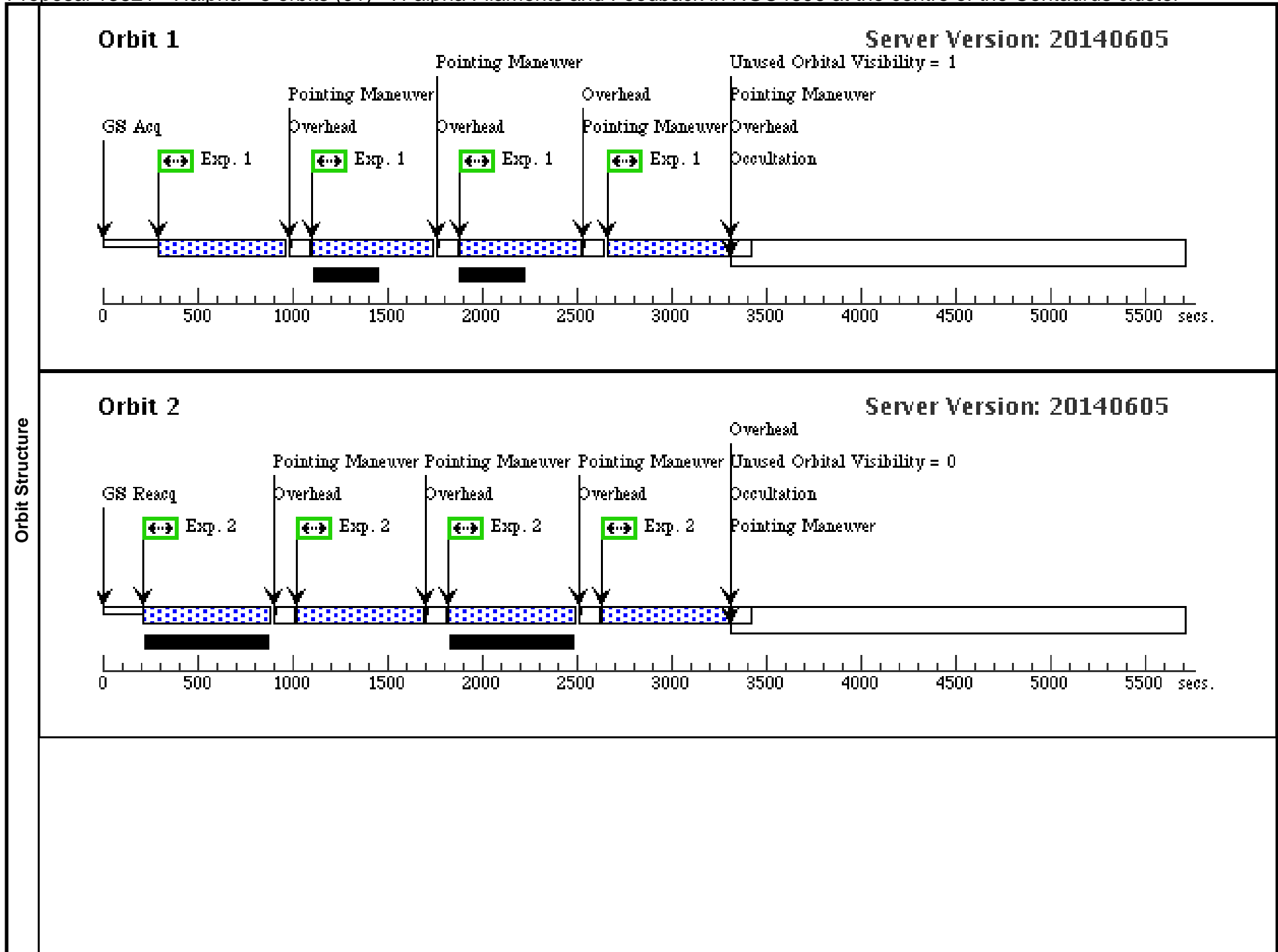
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Proposal 13821 - Halpha - 5 orbits (01) - H-alpha Filaments and Feedback in NGC4696 at the centre of the Centaurus cluster

Wed Oct 15 01:05:41 GMT 2014

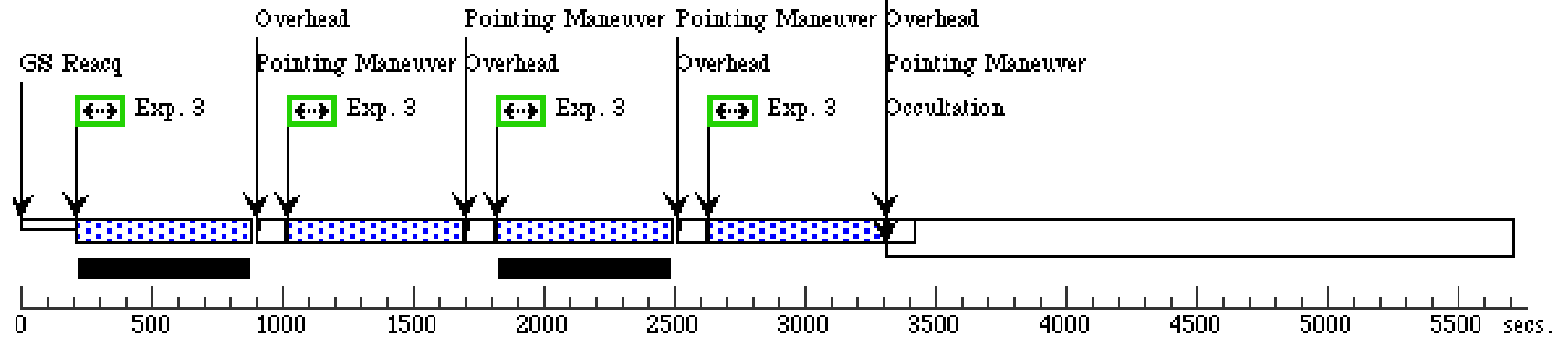
Visit	<b>Proposal 13821, Halpha - 5 orbits (01), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
	(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1), (2), (3), (4), (5)					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	NGC-4696	RA: 12 48 49.2700 (192.2052917d) Dec: -41 18 39.01 (-41.31084d) Equinox: J2000	Redshift: 0.00987	V=21.0	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 1-1 in Halpha - 5 orbits (01) (1)	643 Secs (2572 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
	2	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 2-2 in Halpha - 5 orbits (01) (1)	671 Secs (2684 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2]
	3	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 3-3 in Halpha - 5 orbits (01) (1)	671 Secs (2684 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[3]
	4	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 4-4 in Halpha - 5 orbits (01) (1)	671 Secs (2684 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[4]
	5	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 5-5 in Halpha - 5 orbits (01) (1)	671 Secs (2684 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[5]



**Orbit 3**

Server Version: 20140605

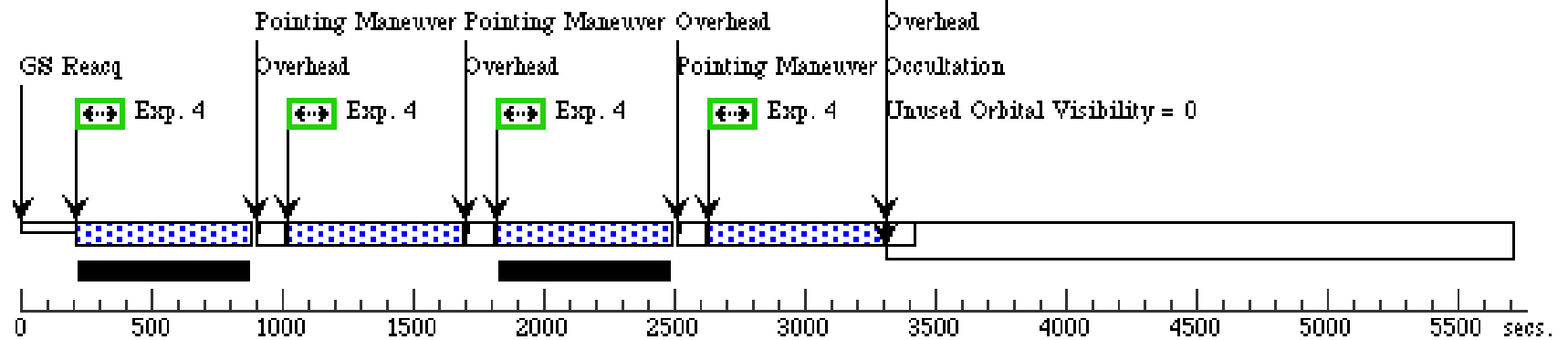
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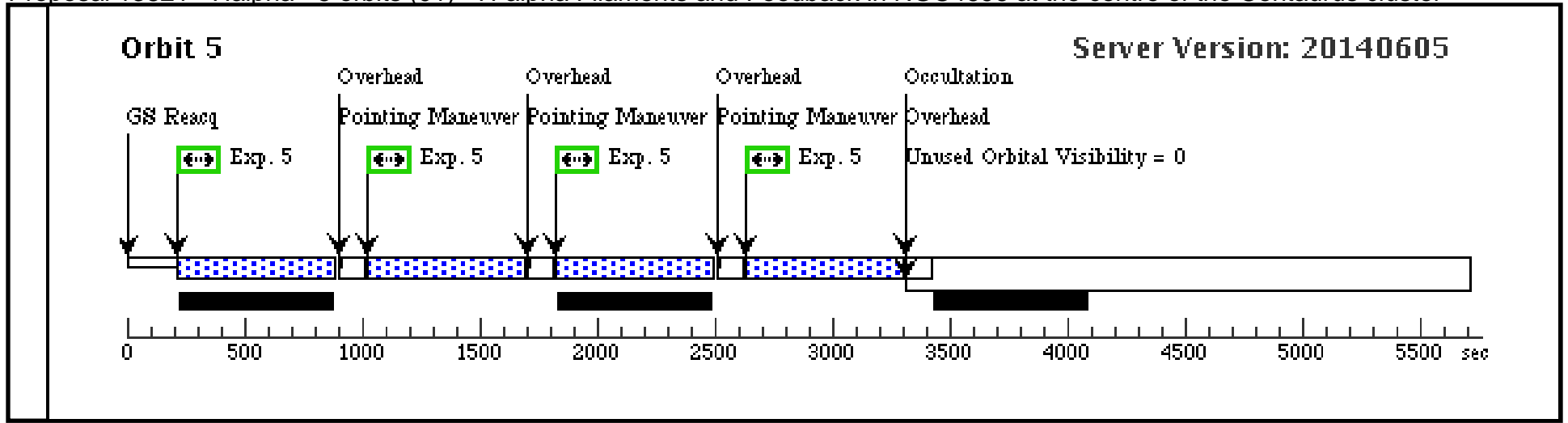


**Orbit 4**

Server Version: 20140605

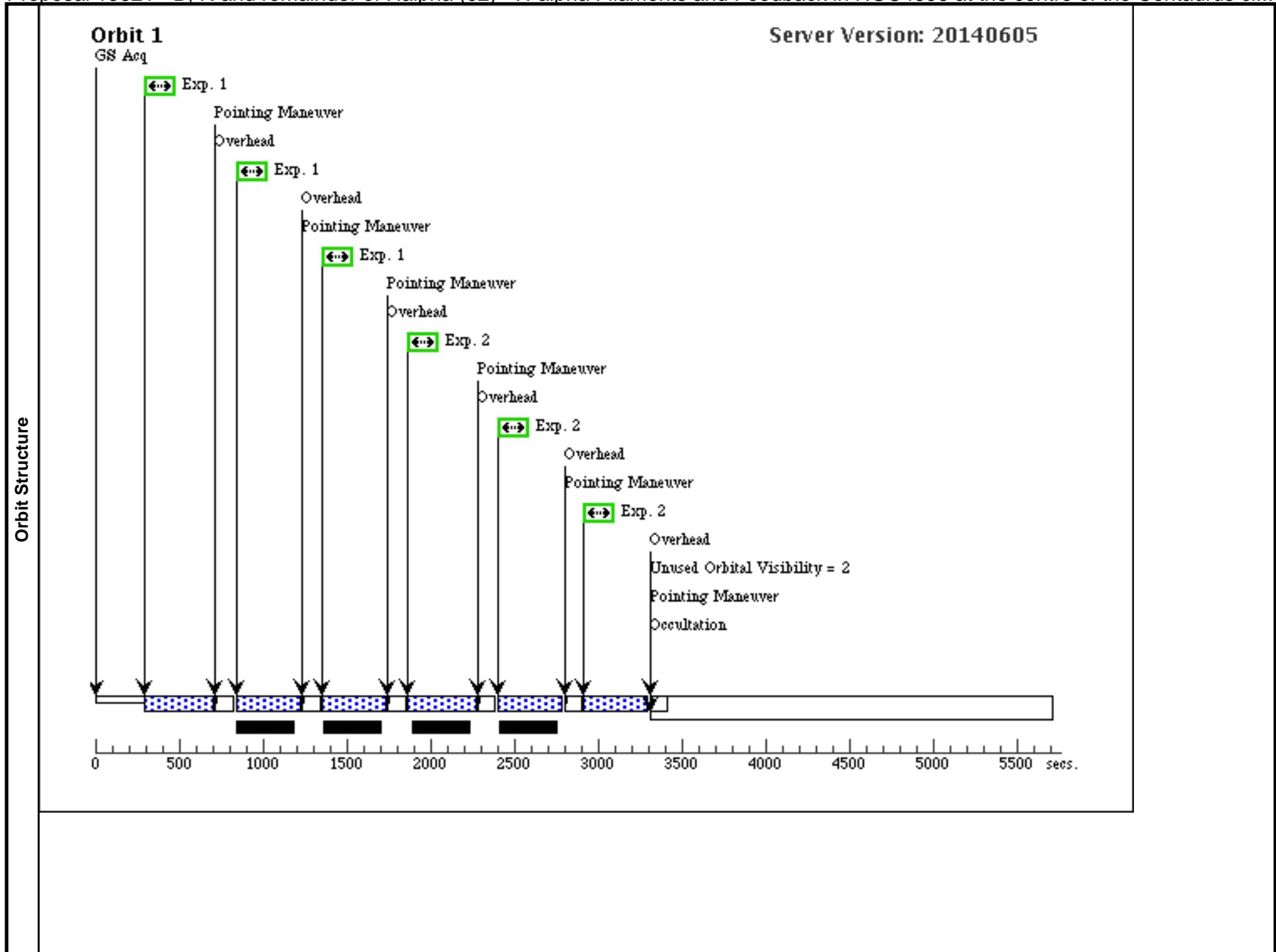
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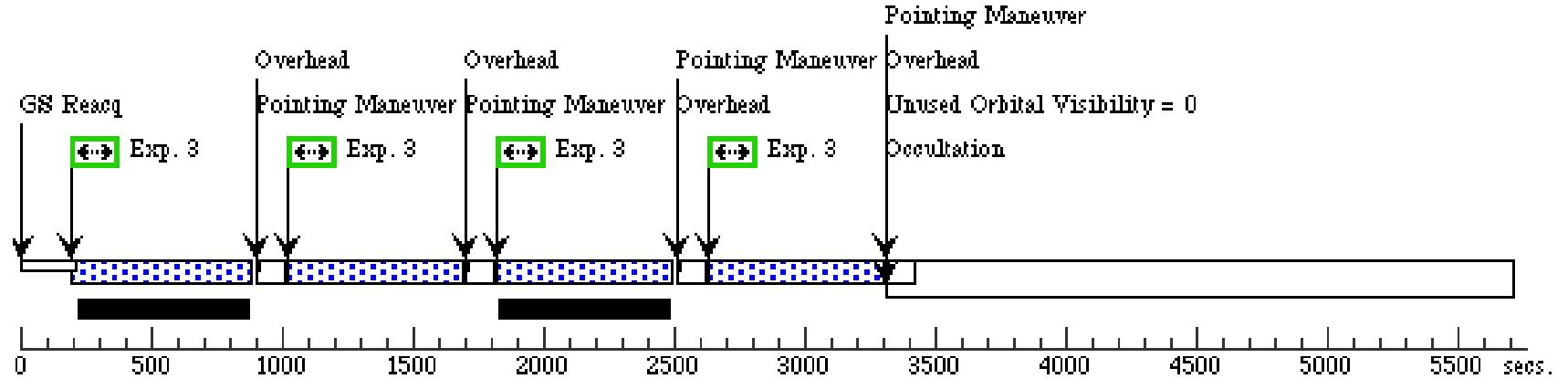
Proposal 13821 - B, R and remainder of Halpha (02) - H-alpha Filaments and Feedback in NGC4696 at the centre of the Centaurus cl...

Visit		<b>Proposal 13821, B, R and remainder of Halpha (02), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)					Wed Oct 15 01:05:42 GMT 2014			
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(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)					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	NGC-4696	RA: 12 48 49.2700 (192.2052917d) Dec: -41 18 39.01 (-41.31084d) Equinox: J2000	Redshift: 0.00987	V=21.0	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=11		Pattern 2, Exps 1-1 in B, R and remainder of Halpha (02) (2)	378 Secs (1134 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)]	[1]
	2	R	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F814W			Pattern 2, Exps 2-2 in B, R and remainder of Halpha (02) (2)	385 Secs (1155 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)]	[1]
	3	B	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F467M	FLASH=8		Pattern 1, Exps 3-3 in B, R and remainder of Halpha (02) (1)	671 Secs (2684 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[2]
4	B	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F467M	FLASH=8		Pattern 1, Exps 4-4 in B, R and remainder of Halpha (02) (1)	671 Secs (2684 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[3]	



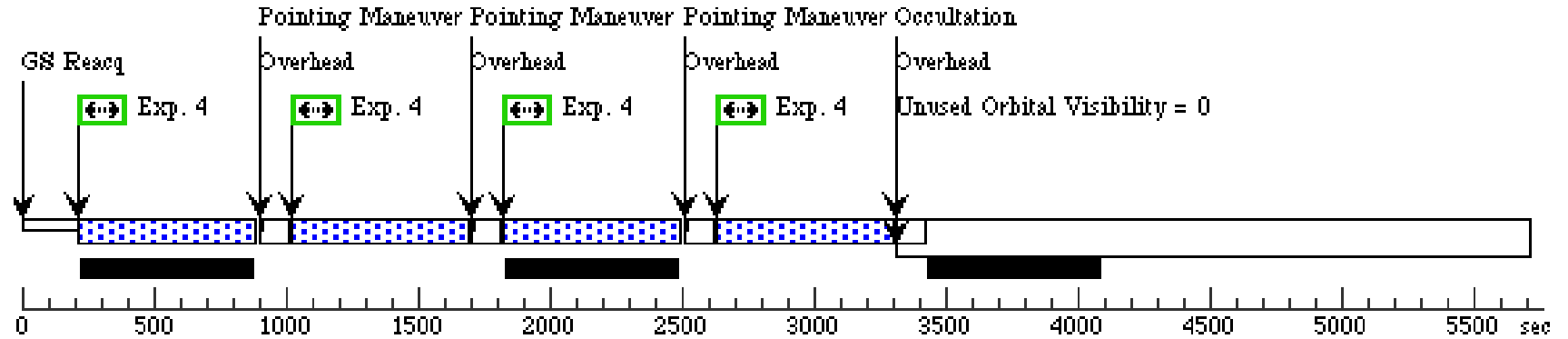
### Orbit 2

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### Orbit 3

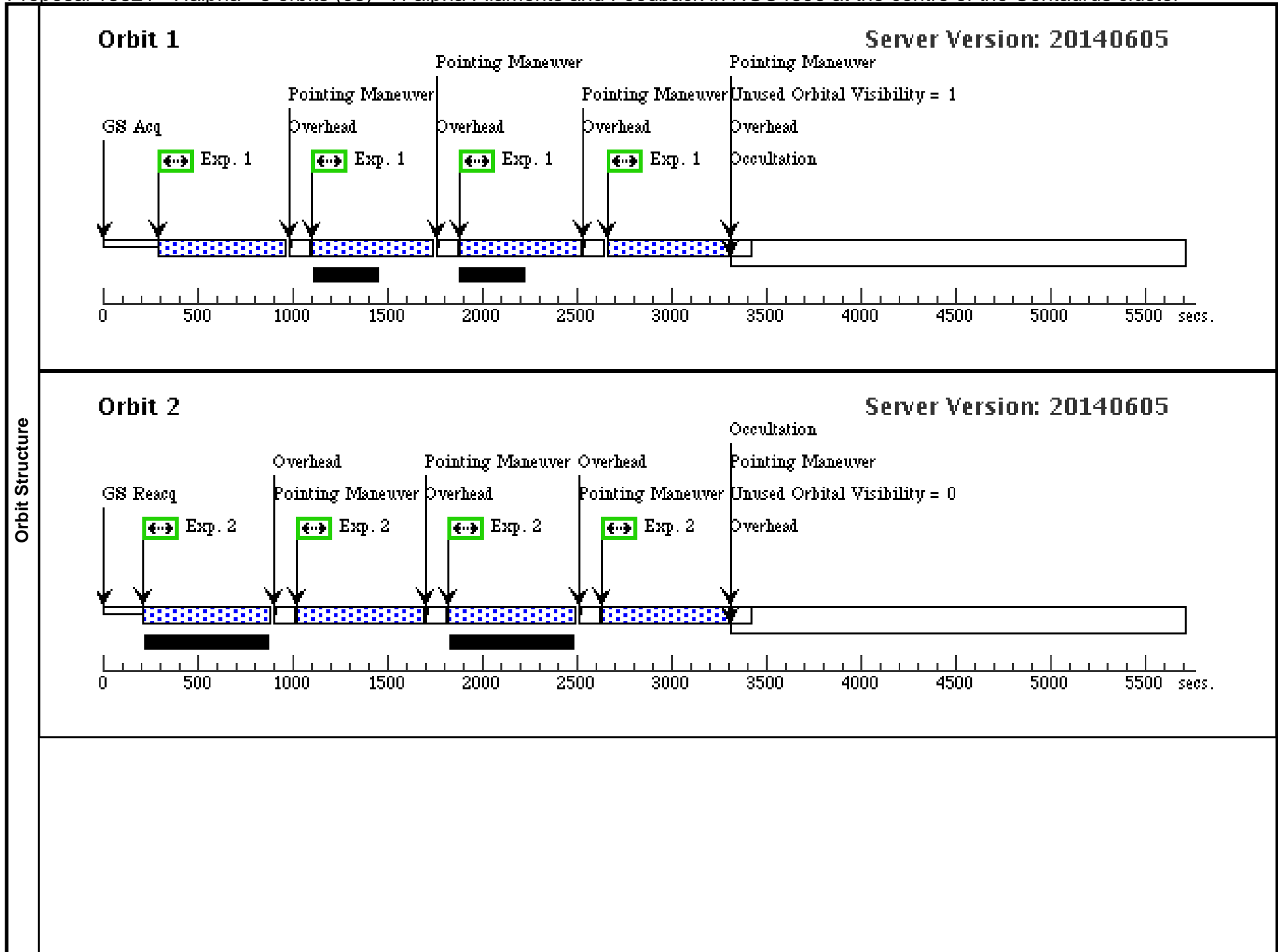
Server Version: 20140605



Proposal 13821 - Halpha - 5 orbits (03) - H-alpha Filaments and Feedback in NGC4696 at the centre of the Centaurus cluster

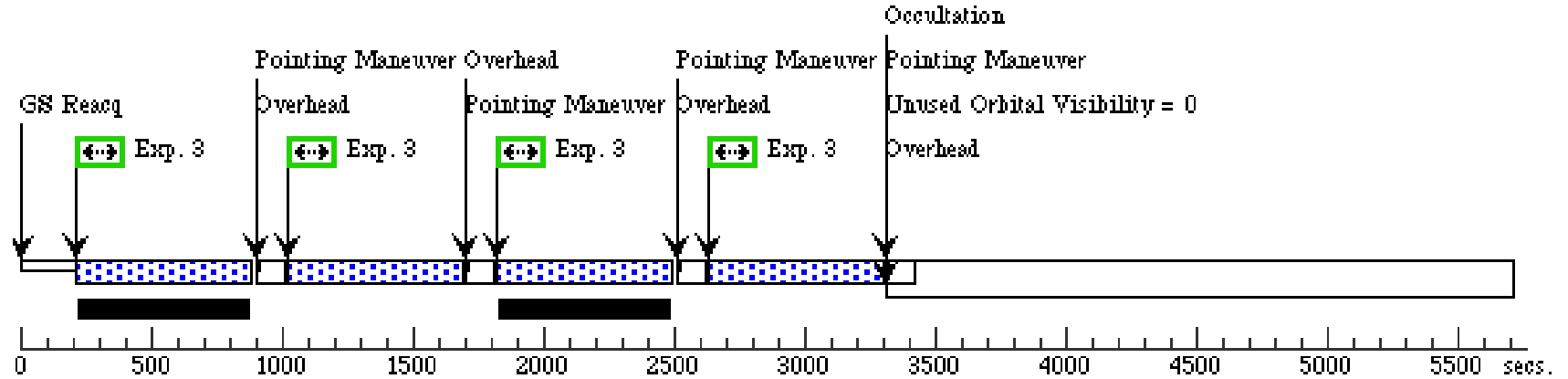
Wed Oct 15 01:05:42 GMT 2014

Visit	<b>Proposal 13821, Halpha - 5 orbits (03), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1), (2), (3), (4), (5)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	NGC-4696	RA: 12 48 49.2700 (192.2052917d) Dec: -41 18 39.01 (-41.31084d) Equinox: J2000	Redshift: 0.00987	V=21.0	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 1-1 in Halpha - 5 orbits (03) (1)	643 Secs (2572 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
	2	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 2-2 in Halpha - 5 orbits (03) (1)	671 Secs (2684 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[2]
	3	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 3-3 in Halpha - 5 orbits (03) (1)	671 Secs (2684 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[3]
	4	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 4-4 in Halpha - 5 orbits (03) (1)	671 Secs (2684 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[4]
	5	Halpha	(1) NGC-4696	WFC3/UVIS, ACCUM, UVIS1	F665N	FLASH=9		Pattern 1, Exps 5-5 in Halpha - 5 orbits (03) (1)	671 Secs (2684 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[5]



**Orbit 3**

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**Orbit 4**

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