11185 - Search for H-poor/He-rich Inclusions and a Solution to the Abundance, Temperature Problems

Cycle: 16, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Robert H. Rubin (PI)	**NASA Ames Research Center**	**rubin@cygnus.arc.nasa.gov**
Prof. Xiao-wei Liu (CoI)	Peking University	liuxw@vega.bac.pku.edu.cn
Dr. Michael J. Barlow (CoI) (ESA Member)	University College London	mjb@star.ucl.ac.uk
Dr. Yiannis G. Tsamis (CoI) (ESA Member)	University College London	ygt@star.ucl.ac.uk

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) M1-42	WFPC2	5	07-May-2008 21:03:13.0	yes
02	(2) M1-42-REPEAT ANY	NIC1 NIC2 NIC3	3	07-May-2008 21:03:41.0	yes
10	(2) M1-42-REPEAT	WFPC2	4	07-May-2008 21:03:57.0	yes

12 Total Orbits Used

ABSTRACT

Our recent abundance survey of a large sample of Galactic planetary nebulae (PNe) has led to the discovery of a group of super-metal-rich nebulae whose spectra are characterized by prominent optical recombination lines (ORLs) from C, N, O, & Ne ions and a large Balmer discontinuity jump. The heavy element abundances derived from ORLs for several PNe are more than an order of magnitude higher than those derived from the traditional method based on collisionally excited lines (CELs), while the Balmer jump yields electron temperatures (Te) significantly lower than values derived from the [O III] 5007/4363 CEL line ratio. A proposition that aspires to explain both the nebular abundance and Te problems is one according to which these nebulae contain (at least) two distinct emission regions - one of "normal" Te (~ 10000 K) and chemical composition (~solar) and another of very low Te that is H-deficient, thus having high helium and metal abundances relative to hydrogen. The latter component emits strong He and heavy element ORLs but essentially no CELs. The consistent picture that emerges from fitting a 2-component photoionization model to the spectroscopic data is that the H-poor component is in high-density inclusions, which provide only a minor fraction of the total nebular mass. We propose to directly detect these inclusions in the planetary nebula M 1-42 using WFPC2 (PC) to make a high spatial resolution image in the He I 5876 A ORL and ratio it to Halpha. With NICMOS (NIC1), we plan to observe the He I 10830 A line, which is substantially collisionally excited, along with Palpha 18760 A. The ratio image of He I 10830 to Palpha is expected to be less likely to show the inclusions, thus serving as an important control to the optical imaging. M 1-42 is one of the most extreme cases of the abundance and Te problem; it is reasonably bright and compact. This program has the potential to resolve a serious challenge to our current understanding of nebular astrophysics.

OBSERVING DESCRIPTION

We have 2 parts to this program - observations with WFPC2 and with NICMOS [primary and coordinated parallel] of the bulge planetary nebula (PN) M 1-42.

WFPC2 Images with the PC

M 1-42 will be covered fully by the Planetary Camera,

which provides a spatial sampling of 0.046", close to the diffraction
limit of HST at the optical wavelengths of our observations.
We take images with four narrow-band filters that cover emission
lines of interest. Individual filters are listed below, as well as the
dominant line they are designed to cover. Exposure times are based
on existing spectroscopy (Liu et al. 2001).

F588N He I 5876 -
This is a very important line and requires the longest time.
Multiple exposures in Visit 1 in 4 orbits will provide for a very robust
CR removal. For the other filters, we have a sufficient number of exposures
to be able to essentially remove all CR-damaged pixels.
We use an A/D gain of 7.

For this filter as well as the others, we use a PATTERN with a standard
2-point dither. This is a single dither from the original pixel position
[say (0,0)] to one offset diagonally (in both x and y) to (5.5,5.5) pixels
for the PC (~0.35"). This is a recommended pattern WFPC2-LINE (section 7.6,
WFPC2 Handbook) in order to minimize loss from chip blemishes and improve
spatial sampling.

F502N [O III] 5007 -
An A/D gain of 15, which provides the potential for a larger dynamic range,
is used for the this line and the other bright lines (Halpha and [N II] 6584).
The dither pattern also provides 2 exposures for CR removal.

F656N Halpha 6565 -
The dither pattern also provides 2 exposures for CR removal.

F658N [N II] 6584 -
The dither pattern also provides 2 exposures for CR removal.

Both F656N and F658N are crucial to separate the contributions
of [N II] 6548 and 6584 (almost as bright as Halpha)
to the F656N bandpass and of the Halpha line to the F658N bandpass.

The central star is very faint (V=17.40, B= 18.30) and was not
even detected in the Liu et al. slit spectra.

All WFPC2 exposures need to be reasonably close in time to promote
pixel registration. This is the reason for Visit 1 with all
5 WFPC2 orbits.

NICMOS Images

We use a single pointing with NIC1 to provide line maps in
He I 10830 A using F108N and F113N (to subtract the adjacent continuum)

and Pa_alpha 18756 A using F187N and F190N (to subtract the adjacent continuum). The respective continuum maps are made by using the F113N and F190N together with off-source measurements taken with the coordinated parallels, albeit at the lower spatial resolution of the NIC2 and NIC3 parallel data. The NIC1 field of view of 11" x 11" covers the bulk of M 1-42. It is somewhat enlarged (to ~12"-square) by our 4-point dither from the original pixel position (0,0) to (23.5,0), (23.5,23.5), (0,23.5) for NIC1 with 0.043" pixels. It is important to have the PN well centered in the NIC1 field-of-view (FOV). Therefore we use NIC1-FIX and require that the 4-point "spiral" dither pattern be CENTERED.

The average surface brightness is based on Liu et al. (2001) spectroscopy, differential extinction analysis, and recombination theory to estimate the Pa_alpha flux from the flux of Halpha and Hbeta [see phase I proposal]. The exposure times are designed to provide a S/N ~10 for the He I and Pa_alpha lines. Equal matching time exposures are taken in the adjacent continuum filters F113N and F190N.

All NICMOS exposures need to be reasonably close in time to promote pixel registration.

Coordinated Parallel NICMOS Images

With NIC1 (F108N/F113N), we do NIC3 (F108N/F113N) parallels and with the NIC1 (F187N/F190N) primaries, NIC2 (F187N/F190N) parallels. These are for the purpose of providing an off-source measurement to subtract from the on-source continuum images only. The respective values for the offset from the centers of NIC1 to NIC2 and NIC3 parallel FOV are 32.59 and 47.78". We note that these are not precision off-source measurements; there is no need to spend the considerable extra time to take off-source measurements with NIC1. We emphasize that even if we do not measure the absolute continuum, this is not at all crucial to our program of measuring the line emission above the continuum and the science of detecting H-deficient [He-rich] inclusions.

Visit

Proposal 11185, Visit 01, completed Thu May 08 01:04:01 GMT 2008

Diagnostic Status: No Diagnostics

Scientific Instruments: WFPC2

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFPC2-LINE	Coordinate Frame=POS-TARG		(1), (4-6)
	Purpose=DITHER	Pattern Orientation=45.0		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.3535	Center Pattern=false		
	Line Spacing=			

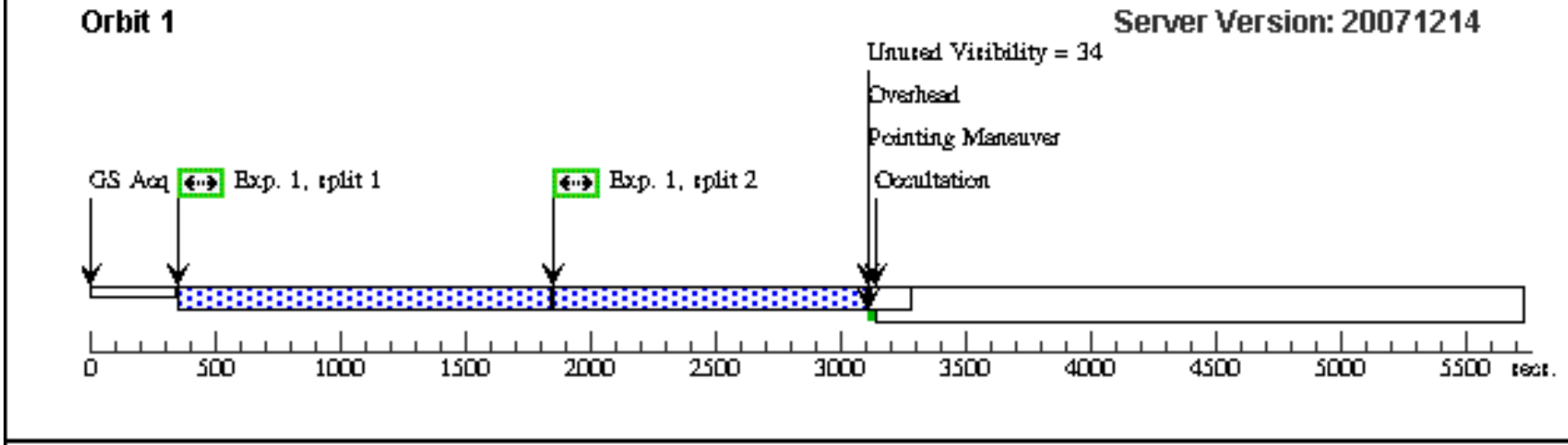
Fixed Targets

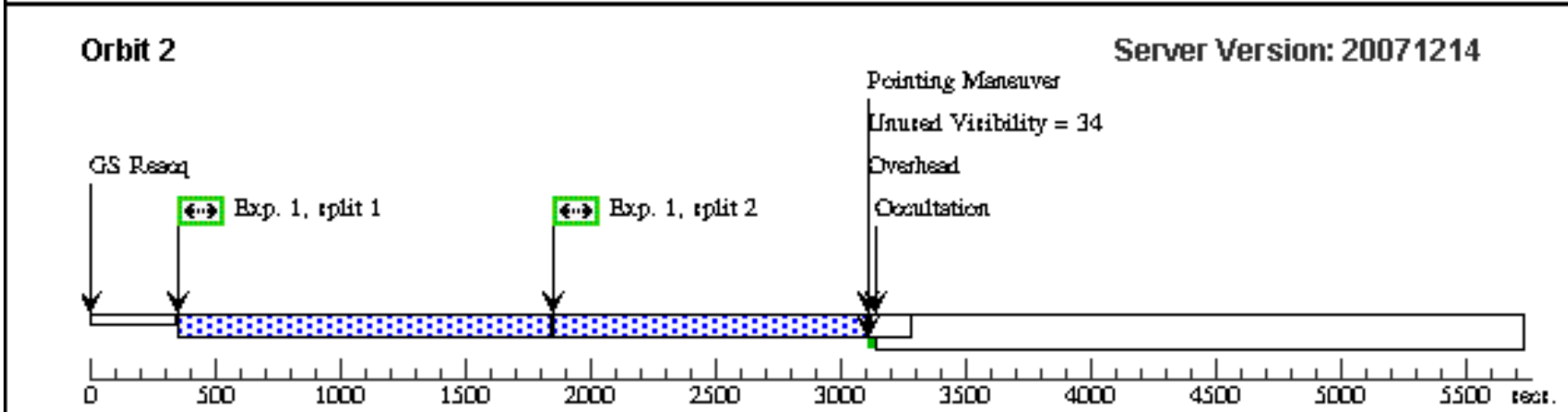
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M1-42	RA: 18 11 5.0280 (272.7709500d) Dec: -28 58 59.33 (-28.98315d) Equinox: J2000		V=17.4+/-0.2 B = 18.3 These are magnitudes of the central star.	Reference Frame: GSC2, FK5

Exposures

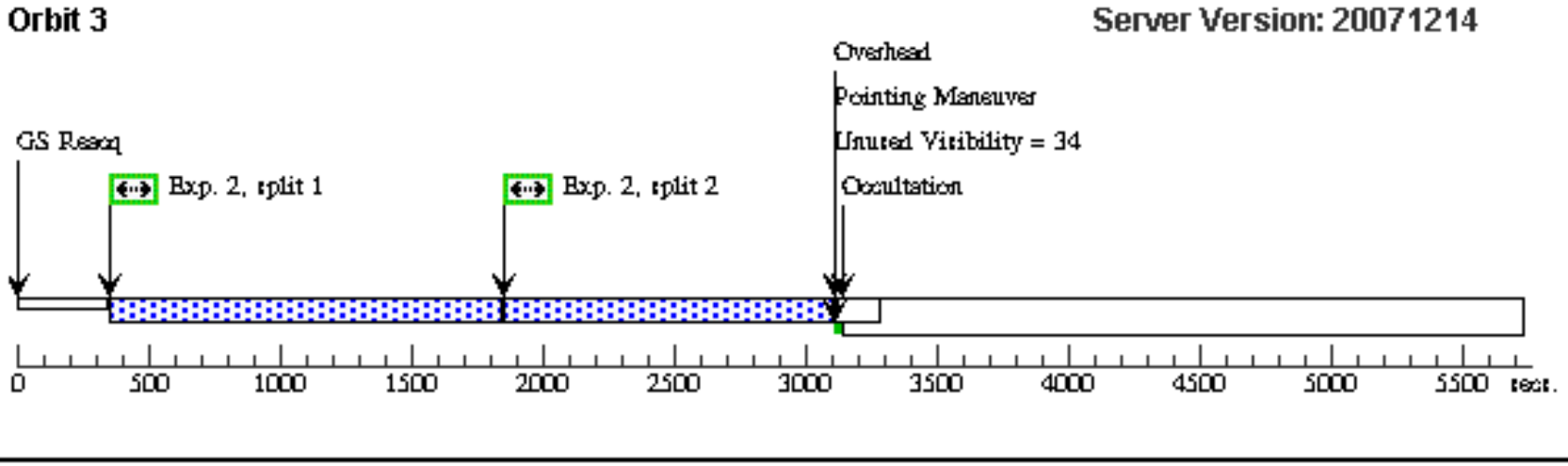
#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) M1-42	WFPC2, IMAGE, PC1-FIX	F588N	ATD-GAIN=7		Pattern 1-1 (1)	2400.0 Secs	
								[==>(Pattern 1, Split 1)] *[==>(Pattern 1, Split 2)]*	***[1]***
								[==>(Pattern 2, Split 1)] *[==>(Pattern 2, Split 2)]*	***[2]***
2		(1) M1-42	WFPC2, IMAGE, PC1-FIX	F588N	ATD-GAIN=7			2400.0 Secs	
								[==>(Split 1)] *[==>(Split 2)]*	***[3]***
3		(1) M1-42	WFPC2, IMAGE, PC1-FIX	F588N	ATD-GAIN=7; CR-SPLIT=NO	POS TARG 0.249,0.249		1600.0 Secs	
								[==>]	***[4]***
4		(1) M1-42	WFPC2, IMAGE, PC1-FIX	F656N	ATD-GAIN=15; CR-SPLIT=NO		Pattern 4-6 (1)	300.0 Secs	
								[==>(Pattern 1)]	***[4]***
								[==>(Pattern 2)]	***[5]***
5		(1) M1-42	WFPC2, IMAGE, PC1-FIX	F658N	CR-SPLIT=NO; ATD-GAIN=15		Pattern 4-6 (1)	160.0 Secs	
								[==>(Pattern 1)]	***[4]***
								[==>(Pattern 2)]	***[5]***
6		(1) M1-42	WFPC2, IMAGE, PC1-FIX	F502N	ATD-GAIN=15; CR-SPLIT=NO		Pattern 4-6 (1)	600.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[5]***

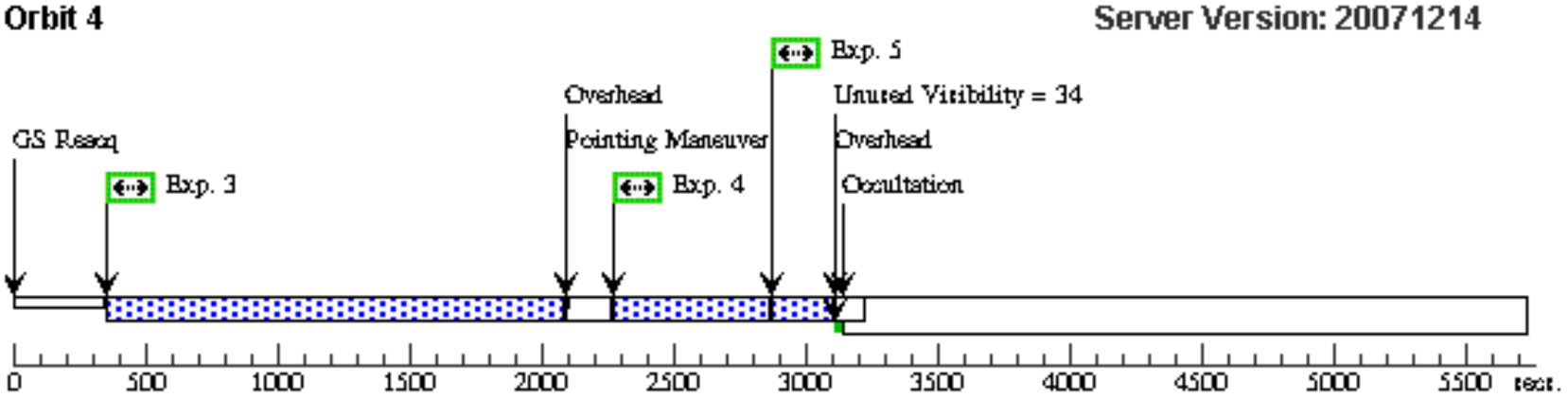
Orbit Structure



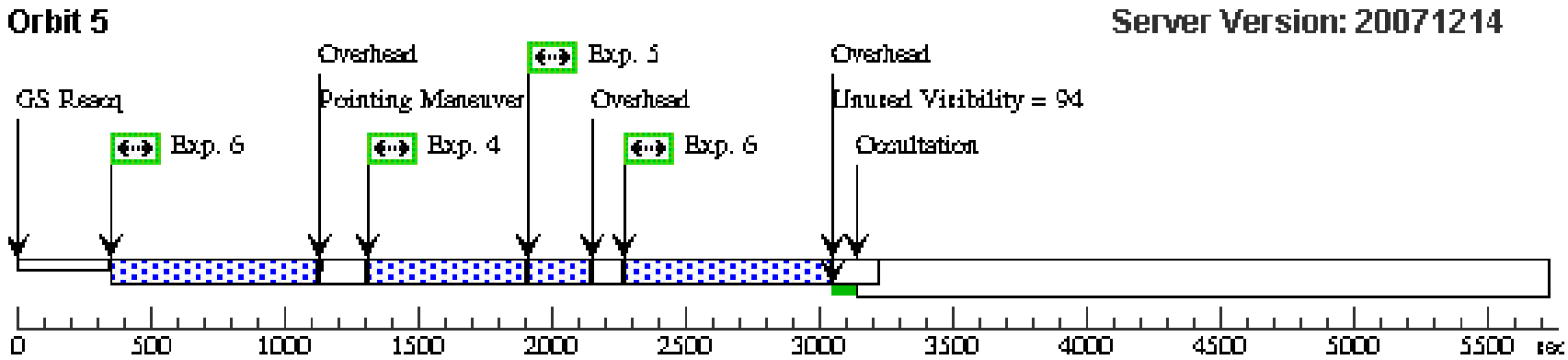


Orbit Structure (continued)





Orbit Structure (continued)



Visit

Proposal 11185, Visit 02, scheduling Thu May 08 01:04:03 GMT 2008

Diagnostic Status: No Diagnostics

Scientific Instruments: NIC2, NIC3, NIC1

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=NIC-SPIRAL-DITH	Coordinate Frame=POS-TARG		(1-2), (3-4), (5-6), (7-8), (9-10), (11-12)
	Purpose=DITHER	Pattern Orientation=0.0		
	Number Of Points=4	Angle Between Sides=		
	Point Spacing=1.0105	Center Pattern=true		
	Line Spacing=			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	M1-42-REPEAT	RA: 18 11 5.0280 (272.7709500d) Dec: -28 58 59.33 (-28.98315d) Equinox: J2000		V=17.4+/-0.2 B = 18.3 These are magnitudes of the central star.	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(2) M1-42-REPEAT	NIC1, MULTIACCUM, NIC1-FIX	F108N	NSAMP=18; SAMP-SEQ=STEP64		Pattern 1-2 (2) Prime + Parallel Group 1-2	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
2	NIC3 F108N	ANY	NIC3, MULTIACCUM, NIC3-FIX	F108N	SAMP-SEQ=STEP64; NSAMP=18		Pattern 1-2 (2) Prime + Parallel Group 1-2	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
3		(2) M1-42-REPEAT	NIC1, MULTIACCUM, NIC1-FIX	F113N	NSAMP=18; SAMP-SEQ=STEP64		Pattern 3-4 (2) Prime + Parallel Group 3-4	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***
4	NIC3 F113N	ANY	NIC3, MULTIACCUM, NIC3-FIX	F113N	SAMP-SEQ=STEP64; NSAMP=18		Pattern 3-4 (2) Prime + Parallel Group 3-4	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***

Comments: ORIENTATION CAN BE anything on ALL parallels.

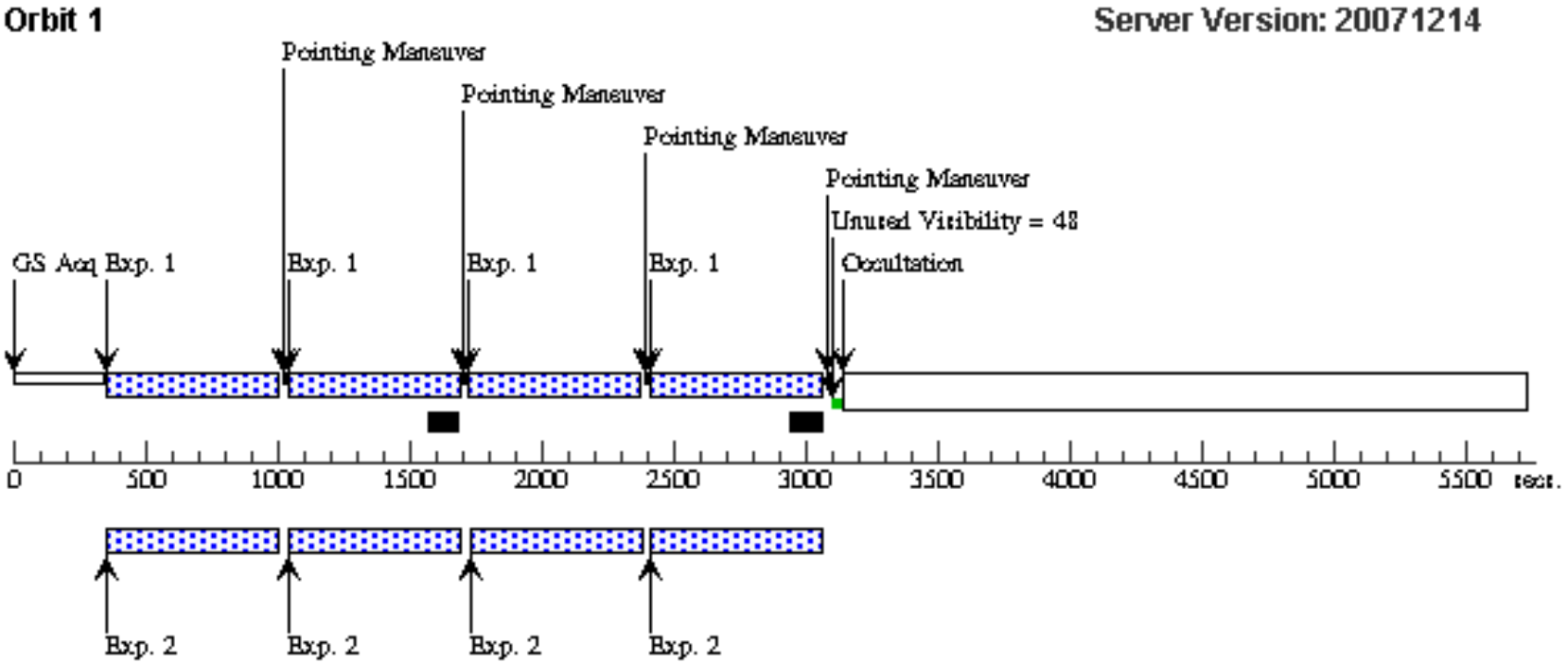
Somewhere we should be entering

TARGET: ANY

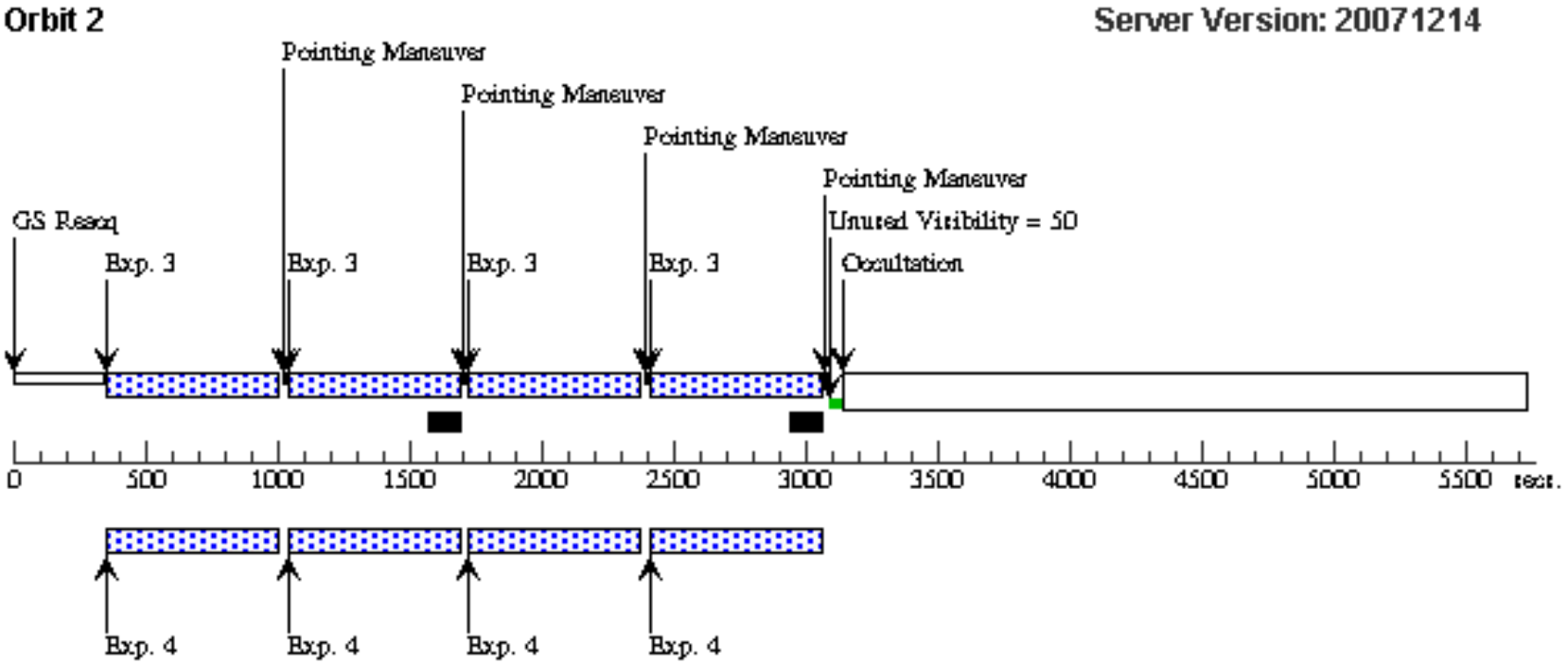
Exposures (continued)

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
5		(2) M1-42-REPEAT	NIC1, MULTIACCUM, NIC1-FIX	F187N	NSAMP=22; SAMP-SEQ=STEP8		Pattern 5-6 (2) Prime + Parallel Group 5-6	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
6	NIC2 F187N	ANY	NIC2, MULTIACCUM, NIC2-FIX	F187N	SAMP-SEQ=STEP8; NSAMP=22		Pattern 5-6 (2) Prime + Parallel Group 5-6	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
7		(2) M1-42-REPEAT	NIC1, MULTIACCUM, NIC1-FIX	F190N	NSAMP=22; SAMP-SEQ=STEP8		Pattern 7-8 (2) Prime + Parallel Group 7-8	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
8	NIC2 F190N	ANY	NIC2, MULTIACCUM, NIC2-FIX	F190N	SAMP-SEQ=STEP8; NSAMP=22		Pattern 7-8 (2) Prime + Parallel Group 7-8	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
9		(2) M1-42-REPEAT	NIC1, MULTIACCUM, NIC1-FIX	F108N	SAMP-SEQ=STEP8; NSAMP=20		Pattern 9-10 (2) Prime + Parallel Group 9-10	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
10		ANY	NIC3, MULTIACCUM, NIC3-FIX	F108N	SAMP-SEQ=STEP8; NSAMP=20		Pattern 9-10 (2) Prime + Parallel Group 9-10	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
11		(2) M1-42-REPEAT	NIC1, MULTIACCUM, NIC1-FIX	F113N	SAMP-SEQ=STEP8; NSAMP=20		Pattern 11-12 (2) Prime + Parallel Group 11-12	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
12		ANY	NIC3, MULTIACCUM, NIC3-FIX	F113N	SAMP-SEQ=STEP8; NSAMP=20		Pattern 11-12 (2) Prime + Parallel Group 11-12	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***

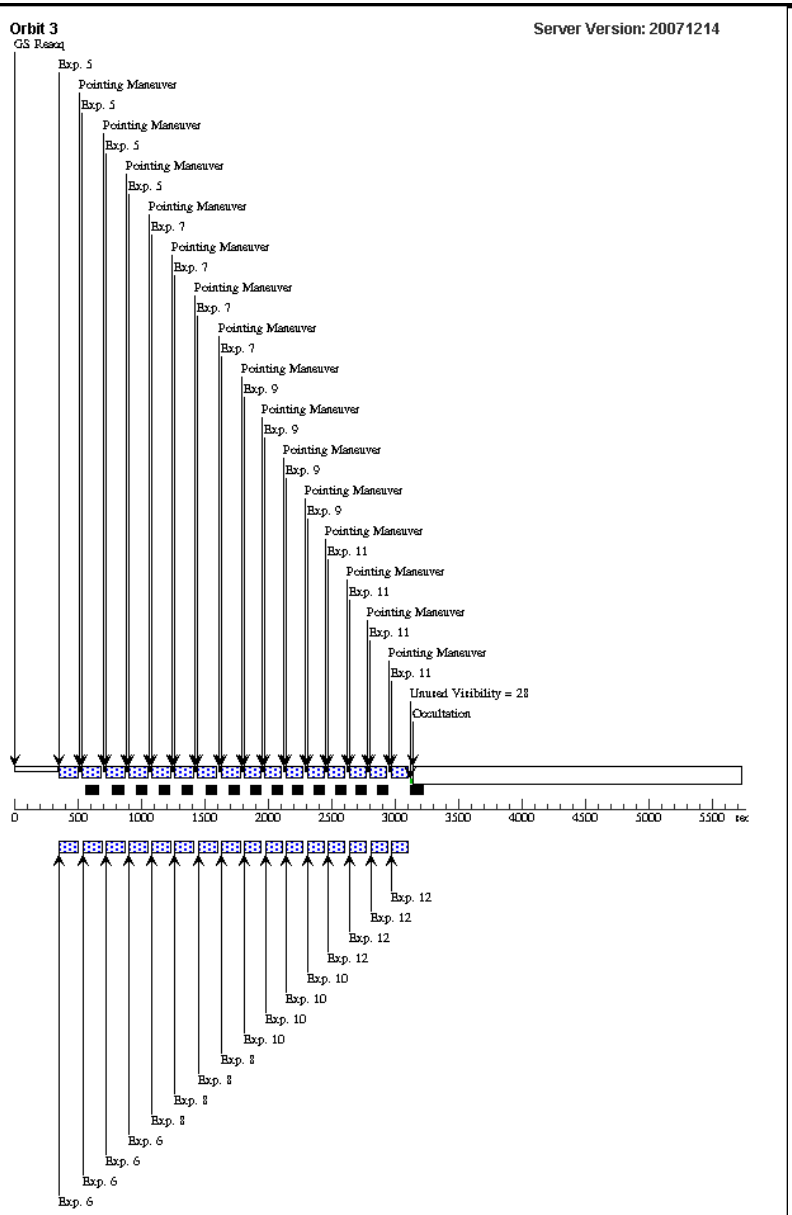
Orbit Structure



Orbit Structure (continued)



Orbit Structure (continued)



Visit

Proposal 11185, Visit 10, implementation Thu May 08 01:04:05 GMT 2008

Diagnostic Status: No Diagnostics

Scientific Instruments: WFPC2

Special Requirements: (none)

Patterns

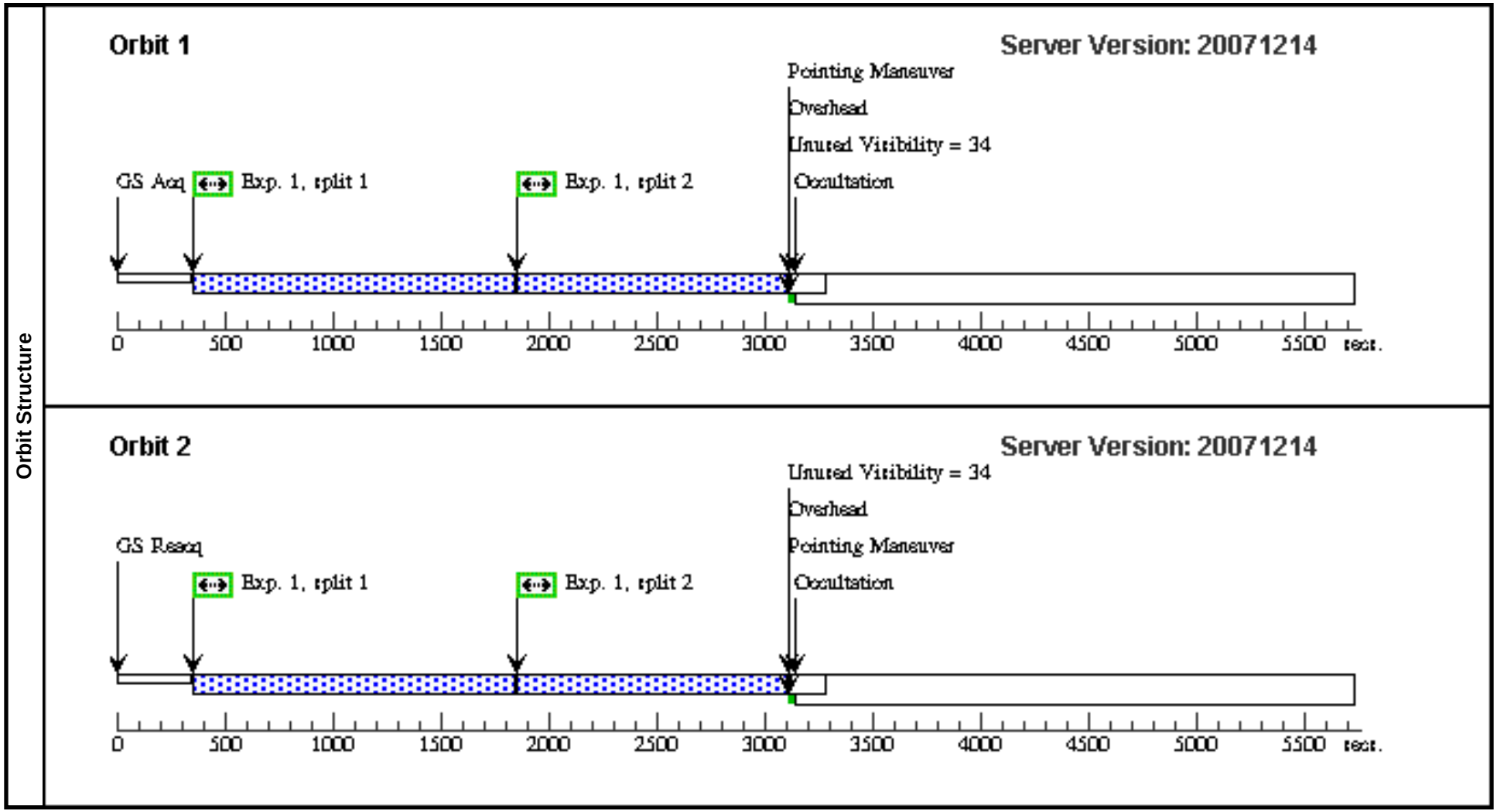
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFPC2-LINE	Coordinate Frame=POS-TARG		(1), (3-5)
	Purpose=DITHER	Pattern Orientation=45.0		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.3535	Center Pattern=false		
	Line Spacing=			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	M1-42-REPEAT	RA: 18 11 5.0280 (272.7709500d) Dec: -28 58 59.33 (-28.98315d) Equinox: J2000		V=17.4+/-0.2 B = 18.3 These are magnitudes of the central star.	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(2) M1-42-REPEAT	WFPC2, IMAGE, PC1-FIX	F588N	ATD-GAIN=7	POS TARG -3,-3	Pattern 1-1 (1)	2400.0 Secs	
								[==>(Pattern 1, Split 1)]	***[1]***
								[==>(Pattern 1, Split 2)]	
								[==>(Pattern 2, Split 1)]	***[2]***
								[==>(Pattern 2, Split 2)]	
2		(2) M1-42-REPEAT	WFPC2, IMAGE, PC1-FIX	F588N	ATD-GAIN=7; CR-SPLIT=NO	POS TARG -3,-3		1200.0 Secs	
								[==>]	***[3]***
3		(2) M1-42-REPEAT	WFPC2, IMAGE, PC1-FIX	F656N	ATD-GAIN=15; CR-SPLIT=NO	POS TARG -3,-3	Pattern 3-5 (1)	300.0 Secs	
								[==>(Pattern 1)]	***[3]***
								[==>(Pattern 2)]	***[4]***
4		(2) M1-42-REPEAT	WFPC2, IMAGE, PC1-FIX	F658N	CR-SPLIT=NO; ATD-GAIN=15	POS TARG -3,-3	Pattern 3-5 (1)	160.0 Secs	
								[==>(Pattern 1)]	***[3]***
								[==>(Pattern 2)]	***[4]***
5		(2) M1-42-REPEAT	WFPC2, IMAGE, PC1-FIX	F502N	ATD-GAIN=15; CR-SPLIT=NO	POS TARG -3,-3	Pattern 3-5 (1)	600.0 Secs	
								[==>(Pattern 1)]	***[4]***
								[==>(Pattern 2)]	


Orbit Structure
Orbit 1
Server Version: 20071214
Pointing Maneuver
Overhead
Unused Visibility = 34
GS Acq
Exp. 1, split 1
Exp. 1, split 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec.
Orbit 2
Server Version: 20071214
Unused Visibility = 34
Overhead
Pointing Maneuver
GS Reacq
Exp. 1, split 1
Exp. 1, split 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec.

Orbit Structure (continued)