14214 - The Suppression of Convection in Magnetic White Dwarfs

Cycle: 23, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Pier-Emmanuel Tremblay (PI) (Contact)	**Space Telescope Science Institute**	**tremblay@stsci.edu**
Dr. Jason S. Kalirai (CoI)	Space Telescope Science Institute	jkalirai@stsci.edu
Prof. Boris T. Gaensicke (CoI) (ESA Member)	The University of Warwick	boris.gaensicke@warwick.ac.uk
Dr. Jeffrey Cummings (CoI)	The Johns Hopkins University	jcummi19@jhu.edu

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) WD2105-820	COS/FUV	1	22-Jul-2015 22:14:24.0	yes
02	(2) WD1544-377	COS/FUV	1	22-Jul-2015 22:14:26.0	yes
03	(3) WD1310+583	COS/FUV	1	22-Jul-2015 22:14:27.0	yes

3 Total Orbits Used

ABSTRACT

Magnetic white dwarfs account for ~10% of the overall remnant population, and contribute an even more significant fraction in the high-mass regime. An understanding of magnetic remnants is critical to derive a precise star formation history and initial mass function in the Galactic disk from the the local volume-complete sample of white dwarfs. The origin of magnetic white dwarfs remains elusive, and they could be remnants of magnetic main-sequence stars or the product of white dwarf mergers, the latter scenario providing constraints on the nature of type Ia supernovae. In the next decade, Gaia will provide precise distances, masses, and luminosities for all magnetic white dwarfs, allowing to trace their evolution path.

We request to test the prediction of our new 3D radiation magnetohydrodynamics simulations of magnetic white dwarf atmospheres that convective energy transfer is suppressed in the line forming regions for B > 5 kG. This result implies a major change in the manner magnetic white dwarfs should be modeled, from the predicted colors to the cooling rates. We propose to observe a cool magnetic white dwarf with B = 10 kG where we predict that convection is supressed at the surface, as well as two standard convective remnants with similar parameters. The radiative and convective solutions are very similar in the optical, but the UV slope will confirm whether convective energy transfer is suppressed. As a consequence, we request 3 HST orbits with COS/FUV to confirm the 3D predictions and set the theoretical framework for the 10,000 magnetic white dwarfs that Gaia will observe.

OBSERVING DESCRIPTION

We request to constrain the slope of the UV flux for the magnetic white dwarf WD 2105-820 (V = 13.60) to determine whether convection is suppressed in the photosphere. Figure 1 of Phase I demonstrates that a low resolution UV spectrum centered at 1800 A, with a coverage of delta lambda = 400 A, is sufficient to constrain the slope in the UV. While previous grids of 1D spectra had an uncertain convective solution due to the presence of free parameters in the 1D mixing-length model (Bergeron et al. 1995), our 3D spectra do not have this shortcoming. As a consequence, we expect an unambiguous difference between the convective and non-convective cases. We therefore require a signal-to-noise ratio of 25 at lambda = 1800 A. We computed a model spectrum for the UV range based on the effective temperature, surface gravity, and V-band magnitude from Gianninas et al. (2011), and fed it into the STIS and COS Exposure Time Calculators (ETCs). We found that the COS G140L/1105 grism yields the best signal, requiring 1 orbit to achieve the desired S/N.

Our spectroscopic COS setup will be able to detect metal pollution in WD 2105-820, which has a small observed abundance of [Ca/H] = -8.6 from high-resolution optical observations (Koester et al. 2005). Such small abundance produces a negligible feedback effect on the structure and will not hamper our science objectives, hence it remains the best target given its small and well characterized magnetic field. A full orbit to reach the maximum S/N is essential to identify possible metal absorption lines in the UV, which could impact the identification of the continuum. Our analysis procedure will consist in fitting iteratively both the requested HST COS observations and our already secured ground based optical observations (Gianninas et al. 2011). We note that the magnetic field is too weak to produce significant Zeeman splitting and hamper the Balmer line fitting, as illustrated by the good match between the published photometric and spectroscopic solutions (Gianninas et al. 2001, Giammichele et al. 2012).

We also request to observe two control targets that are not know to be magnetic and should have the convective solution from Figure 1 of phase I.

We have scanned the White Dwarf Catalog (McCook & Sion 1999) and the local 20 pc sample (Giammichele et al. 2012) for targets, requesting that 9750 < Teff (K) < 11,000. We selected the brightest, single, and non-pulsating pure-hydrogen WDs in the range. The first object is WD 1544-377 with V = 13.0, Teff = 10,610 +/- 151 K and log g = 7.91 +/- 0.04 and the second target is WD 1310+583 with V = 14.1, Teff = 10,682 K +/- 156 and log g = 8.10 +/- 0.05. The atmospheric parameters are derived from precise optical observations (Giammichele et al. 2012). Their brightness is similar to that of our primary magnetic target, hence they also require one orbit with COS G140L/1105 to achieve the science goals. We note that our control targets have no spectropolarimetric observations to confirm that they have no magnetic fields below 10 kG. No WD in the Teff range of interest has a firm non-detection. Only the much fainter WD 2333-049 (V = 15.9) has an upper limit of 10 kG (Landstreet et al. 2012), which is not enough to rule out a radiative atmosphere. However, the probability that both our control targets harbor a kG-range field is estimated at <1% (Landstreet et al. 2012), and we will request ground based spectropolarimetric observations to reach an upper limit of 1 kG, which has been shown to be feasible at the brightness of our targets.

Our targets have never been observed in the UV, and while a few magnetic WDs have been observed with COS, they usually have Teff values large enough that convection is not predicted for both the magnetic and non-magnetic cases. We found one cool magnetic object (WD 2316+123 with Teff ~ 11,000 K), although it has a much stronger magnetic field of B ~ 45 MG with strong Zeeman line splitting in the optical, making it difficult to fit the object and predict an accurate UV flux. Furthermore, the COS data is limited to lambda < 1700 A, where Lyman- pseudo-molecular satellites are found. It is currently difficult to predict the shape of these satellites in the presence of a strong magnetic field. Nevertheless, we will use this archive data as a check of our results.

All our targets have high proper motions and we will acquire images in 2015 at Liverpool Telescope (WD1310+583) and Prompt Telescope (WD 2105-820 and WD 1544-374). Once we have reliable coordinates and proper motions, we don't need the ACQ/SEARCH, which saves exposure time.

The control target WD 1544-374 (HD 140901B) is a companion to the main-sequence star HD 140901 of type G6V and V = 6.01 with a seperation of 15 arcsec. The wide binary was first identified by Wegner 1973, MNRAS, 163, 381 and has been referenced as such in 50+ papers. Subsequent observations leave little doubt that it is a physical pair (see, e.g., Catalan et al. 2008, A&A, 477, 213). BOT does not give any warning with GALEX fluxes when no PM is applied, which should be the correct case since both bright objects in the field have common PM. Nervertheless, feeding ETC with a Kurucz Models G5V model (COS.sa.727761) confirms that the FUV flux of the companion is not a safety problem. Finally, observed GALEX FUV fluxes in the field do not trigger any safety warning, and only fluxes extrapolated to the NUV suggest problems (but they assume the wrong spectral types for the objects in the field).

Visit

Proposal 14214, WD2105-820 (01) Thu Jul 23 02:14:28 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV

Special Requirements: (none)

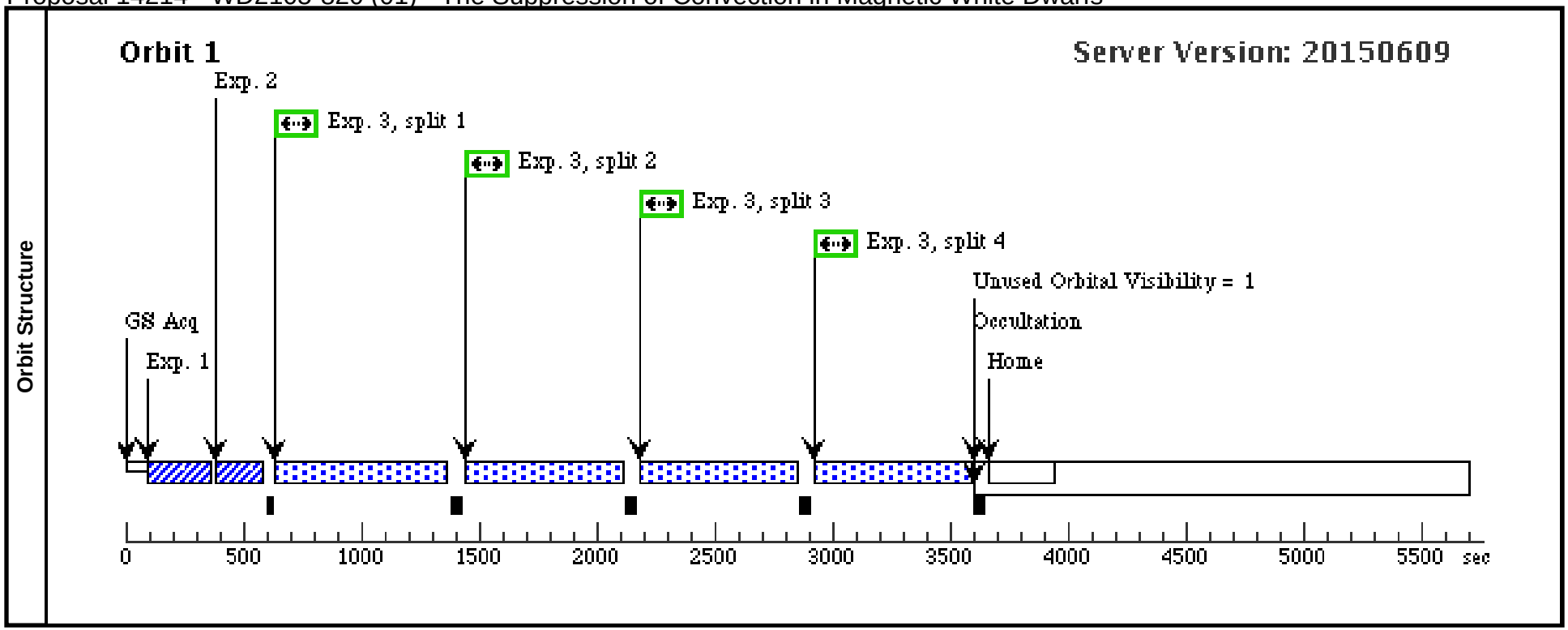
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	WD2105-820	RA: 21 13 16.8164 (318.3200683d) Dec: -81 49 12.80 (-81.82022d) Equinox: J2000	Proper Motion RA: 252 mas/yr Proper Motion Dec: -374 mas/yr Parallax: 0.0586" Epoch of Position: 2000 Redshift: 0	V=13.60+/-0.05	Reference Frame: ICRS

Comments: Coordinates and proper motions from PPMXL. We will acquire an image at Prompt Telescope to confirm the proper motion.
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.717576)	(1) WD2105-820	COS/FUV, ACQ/PEAKXD, PSA	G140L 1105 A				10.0 Secs (10 Secs) *[==>]*	 ***[1]***
2	(COS.sa.717576)	(1) WD2105-820	COS/FUV, ACQ/PEAKD, PSA	G140L 1105 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=DEF			10.0 Secs (10 Secs) *[==>]*	 ***[1]***
3	(COS.sp.727789)	(1) WD2105-820	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2000; FP-POS=ALL			615 Secs (2460 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	 ***[1]***


Orbit Structure
Orbit 1
Server Version: 20150609
Exp. 2
Exp. 3, split 1
Exp. 3, split 2
Exp. 3, split 3
Exp. 3, split 4
Unused Orbital Visibility = 1
GS Acq
Occultation
Exp. 1
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 14214, WD1544-377 (02) Thu Jul 23 02:14:29 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV

Special Requirements: (none)

Comments: There is a bright V = 6.01 companion of type G6V at 15 arsec. Feeding ETC with a Kurucz Models G5V model (COS.sa.727761) confirms that the NUV flux of this star is not a problem. See also the last paragrah of the description of the observations.

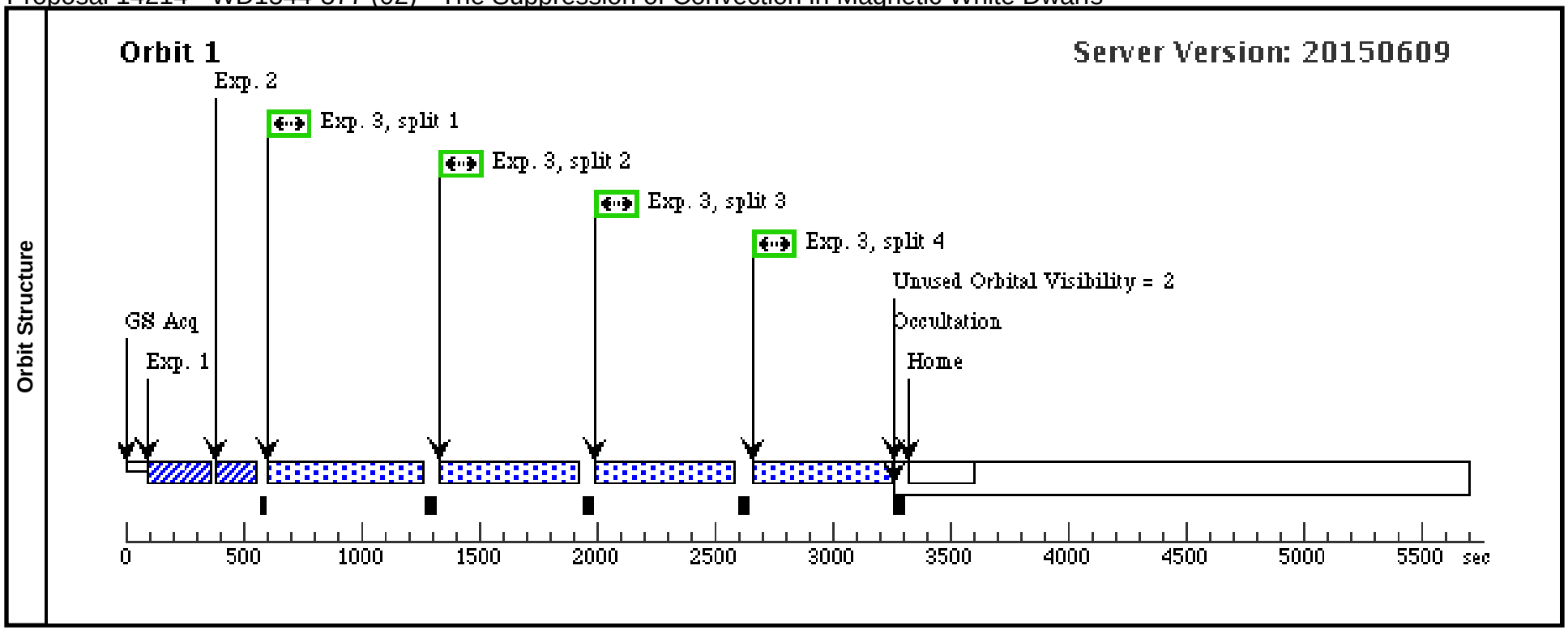
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	WD1544-377	RA: 15 47 30.0700 (236.8752917d) Dec: -37 55 8.11 (-37.91892d) Equinox: J2000	Proper Motion RA: -410 mas/yr Proper Motion Dec: -213 mas/yr Parallax: 0.0656" Epoch of Position: 2000	V=13.0+/-0.05	Reference Frame: ICRS

Comments: Proper motions from PPMXL (from G-star companion). Coordinates from the SIMBAD database. We will acquire an image at Prompt Telescope to confirm the proper motion. Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.717577)	(2) WD1544-377	COS/FUV, ACQ/PEAKXD, PSA	G140L 1105 A				5 Secs (5 Secs) *[==>]*	 ***[1]***
2	(COS.sa.717577)	(2) WD1544-377	COS/FUV, ACQ/PEAKD, PSA	G140L 1105 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=DEF			5 Secs (5 Secs) *[==>]*	 ***[1]***
3	(COS.sp.727790)	(2) WD1544-377	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=ALL; BUFFER-TIME=2000			538 Secs (2152 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	 ***[1]***


Orbit Structure
Orbit 1
Server Version: 20150609
Exp. 2
Exp. 3, split 1
Exp. 3, split 2
Exp. 3, split 3
Exp. 3, split 4
Unused Orbital Visibility = 2
Occultation
GS Acq
Exp. 1
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 14214, WD1310+583 (03) Thu Jul 23 02:14:29 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV

Special Requirements: (none)

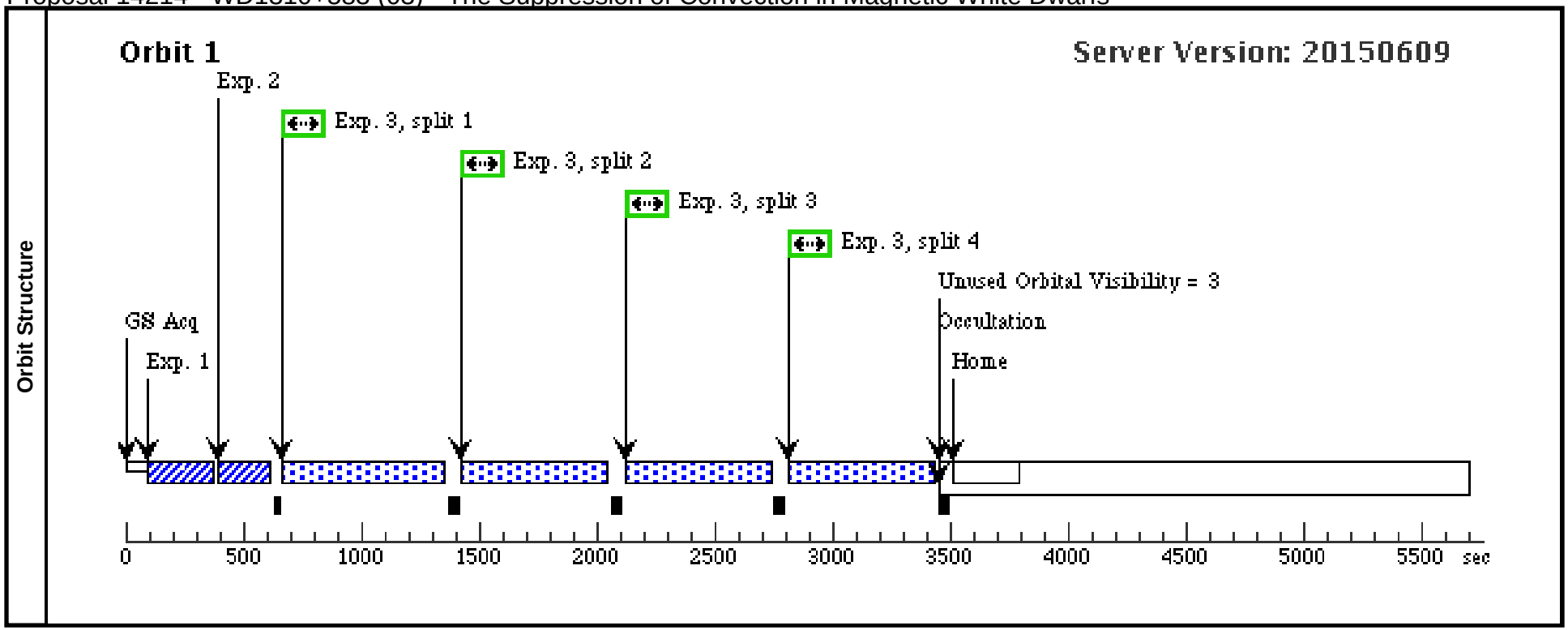
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	WD1310+583	RA: 13 12 57.9053 (198.2412721d) Dec: +58 05 11.16 (58.08643d) Equinox: J2000	Proper Motion RA: 191 mas/yr Proper Motion Dec: -83 mas/yr Parallax: 0.040" Epoch of Position: 2000 Redshift: 0	V=14.1+/-0.05	Reference Frame: ICRS

Comments: Coordinates and proper motions from PPMXL. We will acquire an image at Liverpool Telescope to confirm the proper motion.
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.717580)	(3) WD1310+583	COS/FUV, ACQ/PEAKXD, PSA	G140L 1105 A				15.0 Secs (15 Secs) *[==>]*	 ***[1]***
2	(COS.sa.717580)	(3) WD1310+583	COS/FUV, ACQ/PEAKD, PSA	G140L 1105 A	STEP-SIZE=0.9; CENTER=DEF; NUM-POS=5			15 Secs (15 Secs) *[==>]*	 ***[1]***
3	(COS.sp.727791)	(3) WD1310+583	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=2000; FP-POS=ALL			570 Secs (2280 Secs) *[==>(Split 1)]* *[==>(Split 2)]* *[==>(Split 3)]* *[==>(Split 4)]*	 ***[1]***


Orbit Structure
Orbit 1
Server Version: 20150609
Exp. 2
Exp. 3, split 1
Exp. 3, split 2
Exp. 3, split 3
Exp. 3, split 4
Unused Orbital Visibility = 3
Occultation
GS Acq
Exp. 1
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec