14100 - A Direct Imaging Experiment to Determine the Origin of H2 Emission from M dwarf Exoplanetary Systems

Cycle: 23, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) GJ832	ACS/SBC	4	07-Jul-2015 21:05:01.0	yes
02	(1) GJ832	ACS/SBC	4	07-Jul-2015 21:05:05.0	yes

8 Total Orbits Used

ABSTRACT

Recent HST-COS observations of M dwarfs hosting exoplanetary systems have detected photo-excited H2 emission in these environments, in contrast to previous HST-STIS and IUE observations of non-planet hosting M dwarfs where no H2 emission is observed. Three plausible origins for this emission include: 1) starspots or the stellar photosphere, 2) the heated atmospheres of orbiting planets, or 3) a second generation circumstellar disk produced by atmospheric mass-loss from the planets in these systems. While direct imaging of exoplanets is extremely challenging in the

visible/IR owing to the large star/planet contrast ratio, we will take advantage of the favorable star/planet contrast ratio in the FUV to ascertain the origin of the H2 emission. This proposal will use multi-band FUV imaging with ACS/SBC to directly image one well-positioned M dwarf exoplanetary system to measure the distribution of the H2 gas: GJ 832, at d = 4.9 pc with a Jovian-mass exoplanet at 0.7 arcseconds separation. Using a combination of F122M, F140LP, and F165LP imaging, we can isolate the relative spatial distributions of Lyman-alpha, C IV, and H2 providing a stellar reference (C IV from the stellar atmosphere) and two tracers that may originate from exoplanets or their evaporated atmospheres (Lyman-alpha and H2). A direct H2 image of GJ 832b or a circumstellar disk would demonstrate a new observational tool for the detection of planetary systems orbiting low-mass stars and possibly a new means of measuring atmospheric mass loss rates.

OBSERVING DESCRIPTION

The H2 Lyman band systems are photoexcited ("pumped") by stellar
Ly photons and have transitions that span the FUV bandpass from 1150 - 1650 Ang, but
the brightest lines reside between 1430 - 1510 Ang. Therefore, in order to image the spatial
origin of the H2 in the GJ 832 system, we wish to isolate this spectral region. In addition,
recent work has explored the spectral characteristics of H I Ly emission from hot Jupiters
(Menager et al. 2013), produced mainly by resonant scattering of the stellar emission line.
To fully understand the H2 excitation conditions, we wish to know the spatial distribution
of both the Ly pumping radiation and the H2 emission, therefore we also require Ly
imaging of the system. Finally, as a control, we wish to isolate one spectral tracer that has
no exoplanetary contribution: C IV emission that is only produced in T ~ 10^5 K gas in the
stellar atmosphere.

All three of these emissions can be isolated using filters on the ACS/SBC. F122M is a
dedicated LyA filter. Combining the long-pass FUV filters on ACS is a well-characterized technique for creating
custom filter bandpasses for FUV imaging (e.g., Hayes et al. 2013; Fleming et al. 2015),
and we propose to apply this technique to isolate H2 and C IV emissions from the GJ 832
system.

Taking the average GJ 832 FUV spectrum, and using the STScI on-line exposure time

calculator, we find that a S/N = 100 per angular resolution element F122M Ly image of GJ 832 can be acquired in Texp = 4500 sec. The remaining ACS/SBC filters are long-pass and include a significant red leak, so a filter difference technique is required to isolate a specific FUV bandpass. Using the filter difference D150 = F140LP - F165LP, we can quantify the spectral contributions to this effective narrow-band image from our existing COS spectra: Si IV (9.5 %), C IV (34.9 %), He II (21.1 %), and the 1430 - 1520 Ang H2 region (14.6 %). The D150 band covers both hot gas and H2 emission, however the hot gas emission (Si IV, C IV, and HeII) arises exclusively in the stellar atmosphere and therefore any detection at the position of the planet in D150 will be attributable to H2.

This spectral assignment will be verified using our existing spectroscopy and potential Ly detection at the planetary position. We note that while the H2 region contains the highest density of photoexcited H2 lines per wavelength, this 14.6% is contaminated by weak S I and N I emission lines from the lower chromosphere of the parent star. The S I and N I make up approximately one-third of the 1430 - 1510 Ang flux. Factoring in the contribution from the neutral metal lines, and taking the count outputs from the on-line ACS exposure time calculator, we estimate that if the entire H2 signal originates from GJ 832b, this signal will be detected at S/N(H2) = (X*0.146*(S/N140)^2) / SQRT((S/N140)^2 + (S/N165)^2), where 0.146 is the 14.6% H2 contribution, X is the 1430 - 1510 Ang flux contributed by H2 fluorescence (X ~ 2/3, measured from the COS data, see previous paragraph), and S/N140 and S/N165 are the F140LP and F165LP signal-to-noise ratios, respectively. Therefore with S/N = 100 in both the F140LP and F165LP images, we expect to detect GJ 832b in H2 to a 7- significance if all of the molecular emission originates on the planet. Similarly, if the molecular emission originates in a second generation disk, we will detect the total emission from the disk using photometric annuli, although the significance will be reduced to 3 - 5 sigma , depending on the angular extent of the disk. Using the observed GJ 832 spectrum and the on-line ACS exposure time calculator, we estimate that S/N = 100 can be achieved in 4500 s with F140LP and 9200s with F165LP.

Visit

Proposal 14100, GJ832-SBC-V01 (01) Wed Jul 08 01:05:07 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/SBC

Special Requirements: (none)

Comments: BOT checked and passed. The only flags are when Aladin mistake the target (GJ 832, M1V) for an O5V star. KF - 06/29/15

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GJ832	RA: 21 33 33.9753 (323.3915638d)	Proper Motion RA: -46.05 mas/yr	V=8.672+/-0.1	Reference Frame: ICRS
	Alt Name1: HD-204961	Dec: -49 00 32.42 (-49.00901d)	Proper Motion Dec: -817.63 mas/yr		
		Equinox: J2000	Parallax: 0.20187"		
			Epoch of Position: 2000		
			Radial Velocity: 4.3 km/sec		

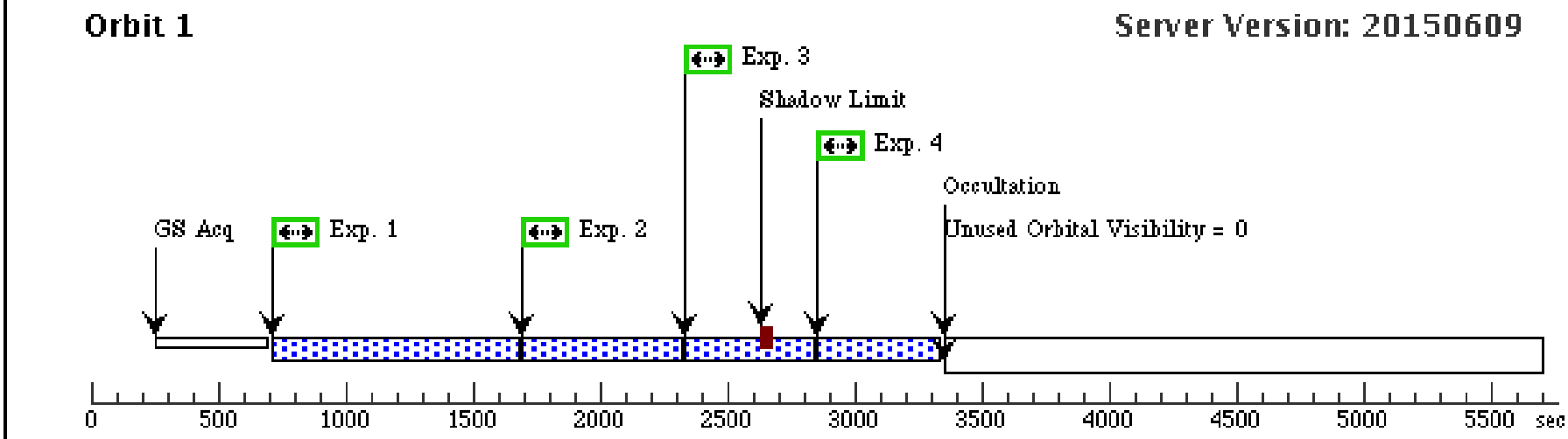
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

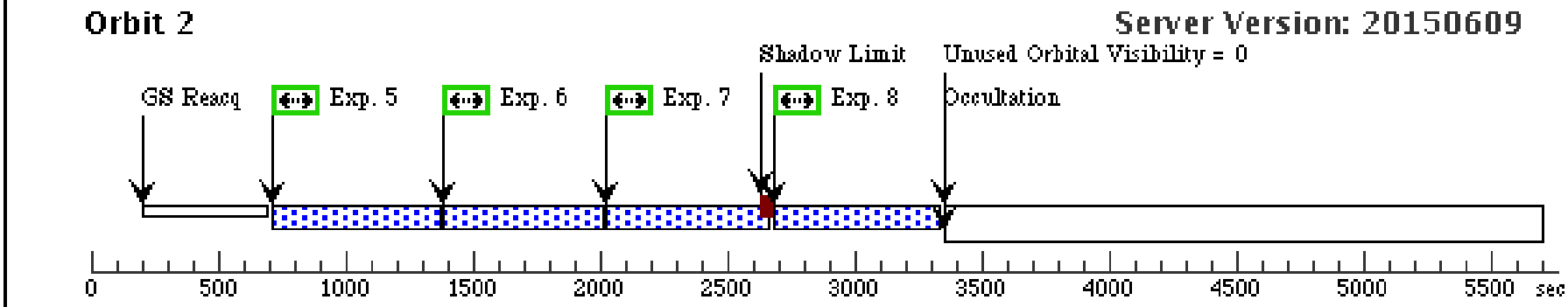
Coord and proper motions - 2007A&A...474..653V
Extended=YES

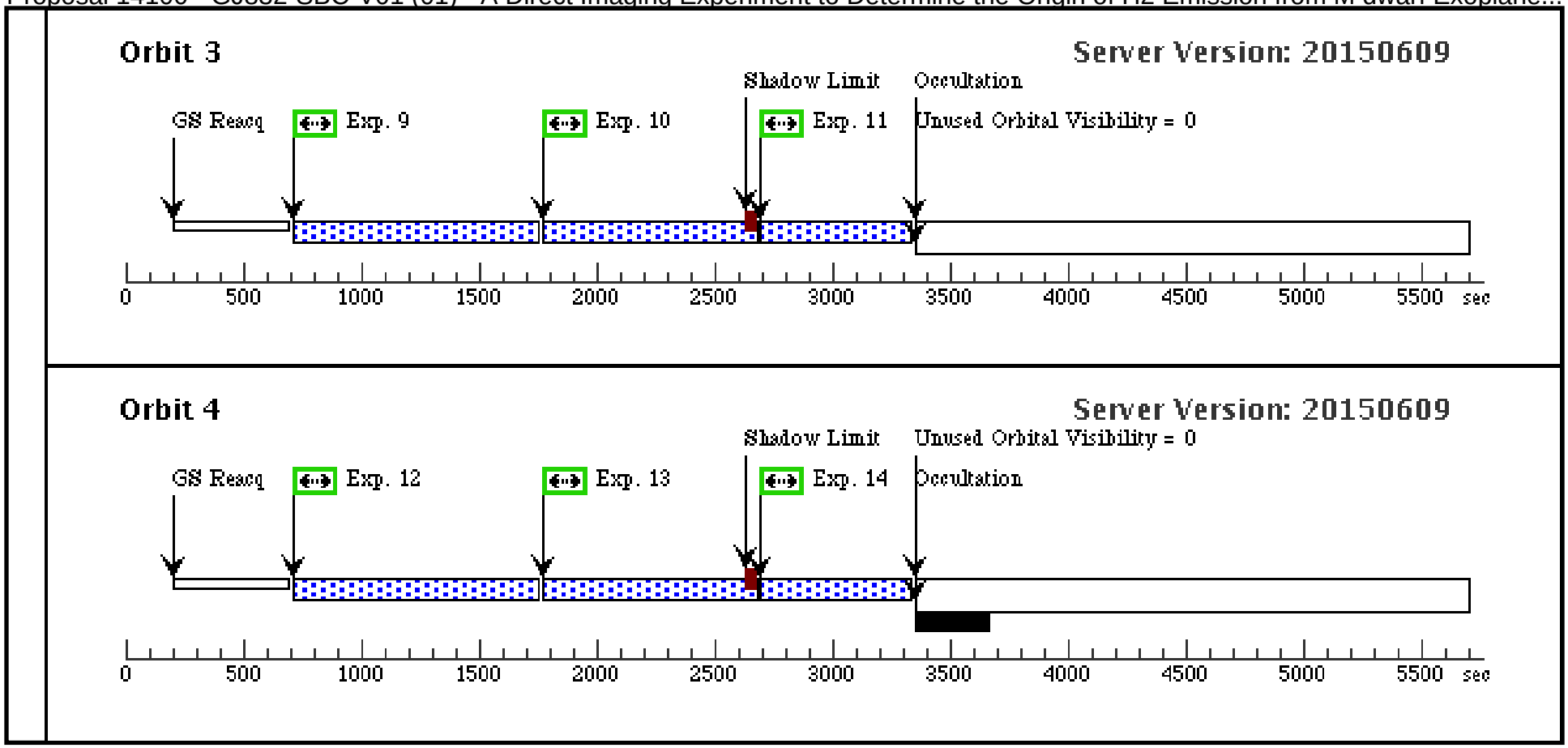
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	V01-F122M_1 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		900 Secs (900 Secs) *[==>]*	*[1]*
2	V01-F122M_2 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		600 Secs (600 Secs) *[==>]*	*[1]*
3	V01-F140LP_1 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				450 Secs (450 Secs) *[==>]*	*[1]*
4	V01-F140LP_2 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				453 Secs (453 Secs) *[==>]*	*[1]*
5	V01-F122M_3 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		600 Secs (600 Secs) *[==>]*	*[2]*
6	V01-F122M_4 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		600 Secs (600 Secs) *[==>]*	*[2]*
7	V01-F165LP_1 (ACS.im.715038)	(1) GJ832	ACS/SBC, ACCUM, SBC	F165LP				600 Secs (600 Secs) *[==>]*	*[2]*
8	V01-F165LP_2 (ACS.im.715038)	(1) GJ832	ACS/SBC, ACCUM, SBC	F165LP				627 Secs (627 Secs) *[==>]*	*[2]*
9	V01-F122M_5 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		1000 Secs (1000 Secs) *[==>]*	*[3]*
10	V01-F140LP_3 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				850 Secs (850 Secs) *[==>]*	*[3]*
11	V01-F165LP_3 (ACS.im.715038)	(1) GJ832	ACS/SBC, ACCUM, SBC	F165LP				589 Secs (589 Secs) *[==>]*	*[3]*
12	V01-F122M_6 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		1000 Secs (1000 Secs) *[==>]*	*[4]*
13	V01-F140LP_4 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				850 Secs (850 Secs) *[==>]*	*[4]*
14	V01-F165LP_4 (ACS.im.715038)	(1) GJ832	ACS/SBC, ACCUM, SBC	F165LP				589 Secs (589 Secs) *[==>]*	*[4]*

Orbit Structure



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Visit

Proposal 14100, GJ832-SBC-V02 (02) Wed Jul 08 01:05:08 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/SBC

Special Requirements: (none)

Comments: BOT checked and passed. The only flags are when Aladin mistake the target (GJ 832, M1V) for an O5V star. KF - 06/29/15

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	GJ832	RA: 21 33 33.9753 (323.3915638d)	Proper Motion RA: -46.05 mas/yr	V=8.672+/-0.1	Reference Frame: ICRS
	Alt Name1: HD-204961	Dec: -49 00 32.42 (-49.00901d)	Proper Motion Dec: -817.63 mas/yr		
		Equinox: J2000	Parallax: 0.20187"		
			Epoch of Position: 2000		
			Radial Velocity: 4.3 km/sec		

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

Coord and proper motions - 2007A&A...474..653V
Extended=YES

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	V02-F122M_1 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		900 Secs (900 Secs) *[==>]*	***[1]***
2	V02-F122M_2 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		600 Secs (600 Secs) *[==>]*	***[1]***
3	V02-F140LP_1 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				450 Secs (450 Secs) *[==>]*	***[1]***
4	V02-F140LP_2 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				453 Secs (453 Secs) *[==>]*	***[1]***
5	V02-F122M_3 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		600 Secs (600 Secs) *[==>]*	***[2]***
6	V02-F122M_4 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		600 Secs (600 Secs) *[==>]*	***[2]***
7	V02-F165LP_1 (ACS.im.715038)	(1) GJ832	ACS/SBC, ACCUM, SBC	F165LP				600 Secs (600 Secs) *[==>]*	***[2]***
8	V02-F165LP_2 (ACS.im.715038)	(1) GJ832	ACS/SBC, ACCUM, SBC	F165LP				627 Secs (627 Secs) *[==>]*	***[2]***
9	V02-F122M_5 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		1000 Secs (1000 Secs) *[==>]*	***[3]***
10	V02-F140LP_3 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				850 Secs (850 Secs) *[==>]*	***[3]***
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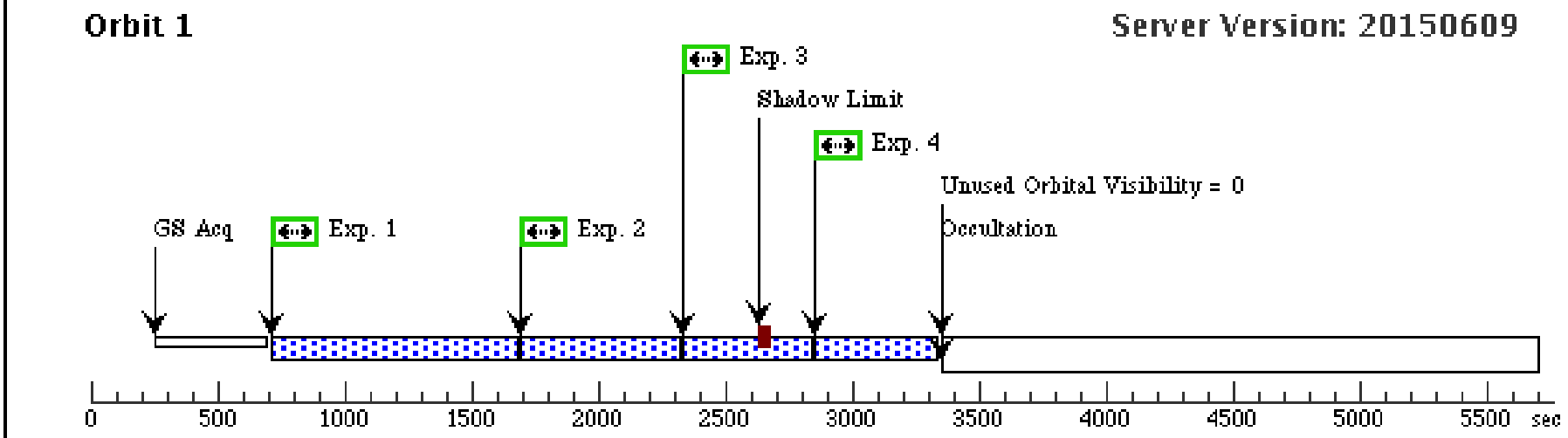
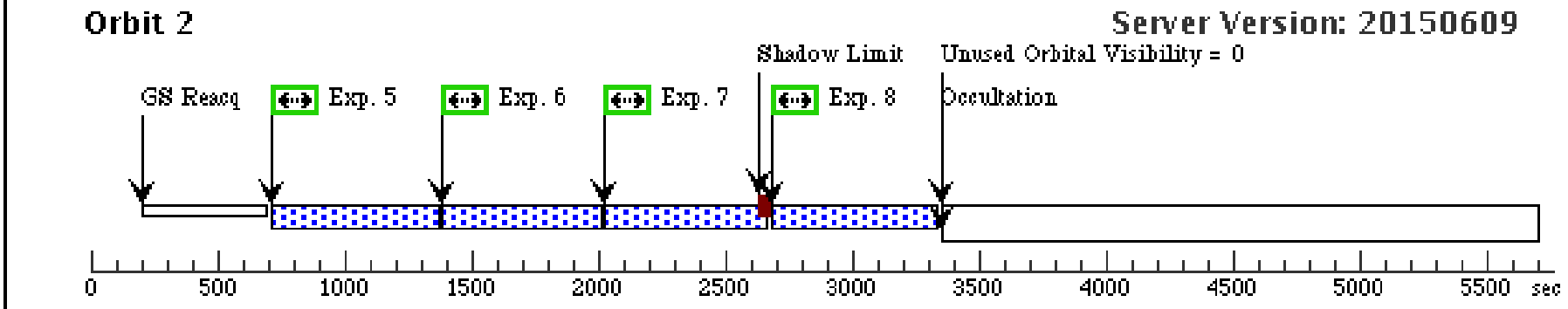
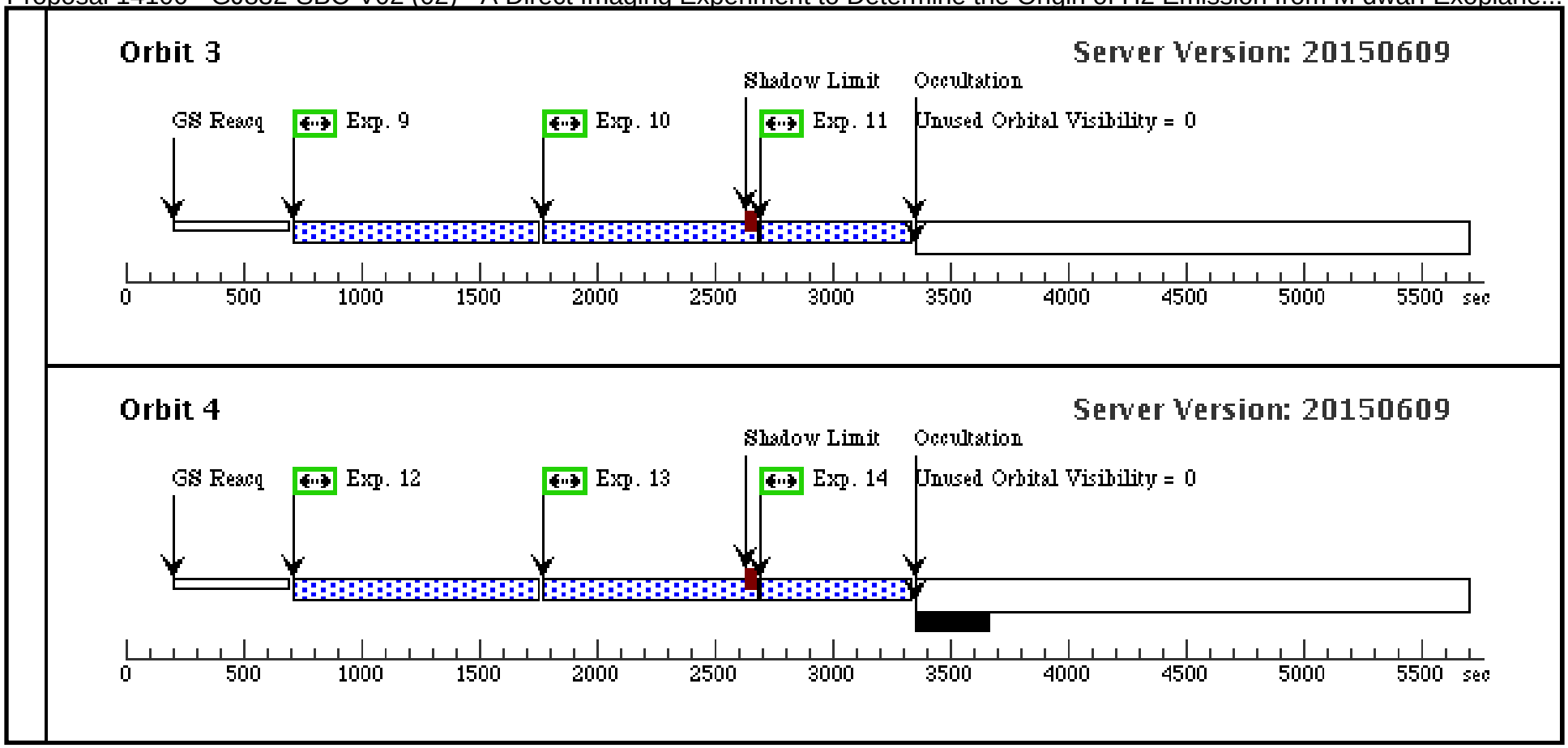
12	V02-F122M_6 (ACS.im.715035)	(1) GJ832	ACS/SBC, ACCUM, SBC	F122M		SHADOW		1000 Secs (1000 Secs) *[==>]*	***[4]***
13	V02-F140LP_4 (ACS.im.715039)	(1) GJ832	ACS/SBC, ACCUM, SBC	F140LP				850 Secs (850 Secs) *[==>]*	***[4]***
14	V02-F165LP_4 (ACS.im.715038)	(1) GJ832	ACS/SBC, ACCUM, SBC	F165LP				589 Secs (589 Secs) *[==>]*	***[4]***

Orbit Structure



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Server Version: 20150609
Shadow Limit
Occultation
GS Reacq
Exp. 9
Exp. 10
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