



## 15921 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Cycle: 27, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

### INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
<b>Peter Senchyna (PI) (Contact)</b>	<b>University of Arizona</b>	<b>senchp@email.arizona.edu</b>
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Dr. Daniel R. Weisz (CoI)	University of California - Berkeley	dan.weisz@berkeley.edu

### 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) J095927.53+304457.7	COS/FUV COS/NUV	2	01-May-2020 10:00:19.0	yes
02	(1) J095927.53+304457.7	COS/FUV COS/NUV	2	01-May-2020 10:00:20.0	yes
03	(1) J095927.53+304457.7	COS/FUV COS/NUV	2	01-May-2020 10:00:21.0	yes
04	(1) J095927.53+304457.7	COS/FUV COS/NUV	2	01-May-2020 10:00:21.0	yes
05	(2) J095930.22+304437.0	COS/FUV COS/NUV	2	01-May-2020 10:00:22.0	yes
06	(2) J095930.22+304437.0	COS/FUV COS/NUV	2	01-May-2020 10:00:23.0	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>
07	(2) J095930.22+304437.0	COS/FUV COS/NUV	2	01-May-2020 10:00:23.0	yes
08	(2) J095930.22+304437.0	COS/FUV COS/NUV	2	01-May-2020 10:00:24.0	yes
23	(1) J095927.53+304457.7	COS/FUV COS/NUV	1	01-May-2020 10:00:24.0	yes

17 Total Orbits Used

## ABSTRACT

Young, extremely metal-poor stellar populations are central to our quest to characterize the faintest star-forming galaxies in the Universe at all redshifts. Ongoing efforts to model the nebular and stellar wind lines in extremely metal-poor ( $< 10\% Z_{\text{sun}}$ ) star-forming galaxies have revealed substantial disagreements with current stellar models. A primary source of this tension is a lack of calibration at low-metallicities: no UV spectrum of an individual O star at  $Z/Z_{\text{sun}} < 0.1$  has ever been taken. We propose to target the brightest two O stars in the extremely metal-poor ( $Z/Z_{\text{sun}} < 0.1$ ) dwarf galaxy Leo A ( $D \sim 700$  kpc) with deep HST/COS FUV spectroscopy. Leo A is the nearest galaxy with a population of massive stars at these metallicities, making these the most efficient observations possible. With these COS observations, we will (i) directly constrain the stellar metallicity (independent of the gas phase) by accessing faint photospheric lines of iron and (ii) for the first time, make a precise measurement of the wind strengths these massive low-metallicity stars drive. Our results have significant implications for massive stellar models in this metallicity regime, and consequently for population synthesis techniques applied to galaxies throughout the universe. This experiment relies entirely on FUV spectra to access crucial massive stellar features inaccessible at other wavelengths, and cannot be conducted in the optical. This will constitute the first observational test of stellar models at the metallicities we expect to encounter regularly in reionization-era galaxies with JWST.

## OBSERVING DESCRIPTION

We will obtain medium-resolution FUV COS spectroscopy for two O stars in the extremely metal-poor nearby dwarf galaxy Leo A. The G160M/1533 grating setting will be used to simultaneously target a set of both stellar wind (O V, Si IV, C IV, and He II) and photospheric absorption lines which are required to address our science goals of constraining the stellar iron abundance and wind strengths. The target stars were identified in HST imaging, and their ICRS coordinates were determined by centroiding the sources in SDSS u-band imaging. Both targets are relatively bright ( $F_{275W} \sim 17.7, 18.0$ ), and can be successfully acquired in ACQ/IMAGE mode with Mirror A with 8 second exposures. In order to

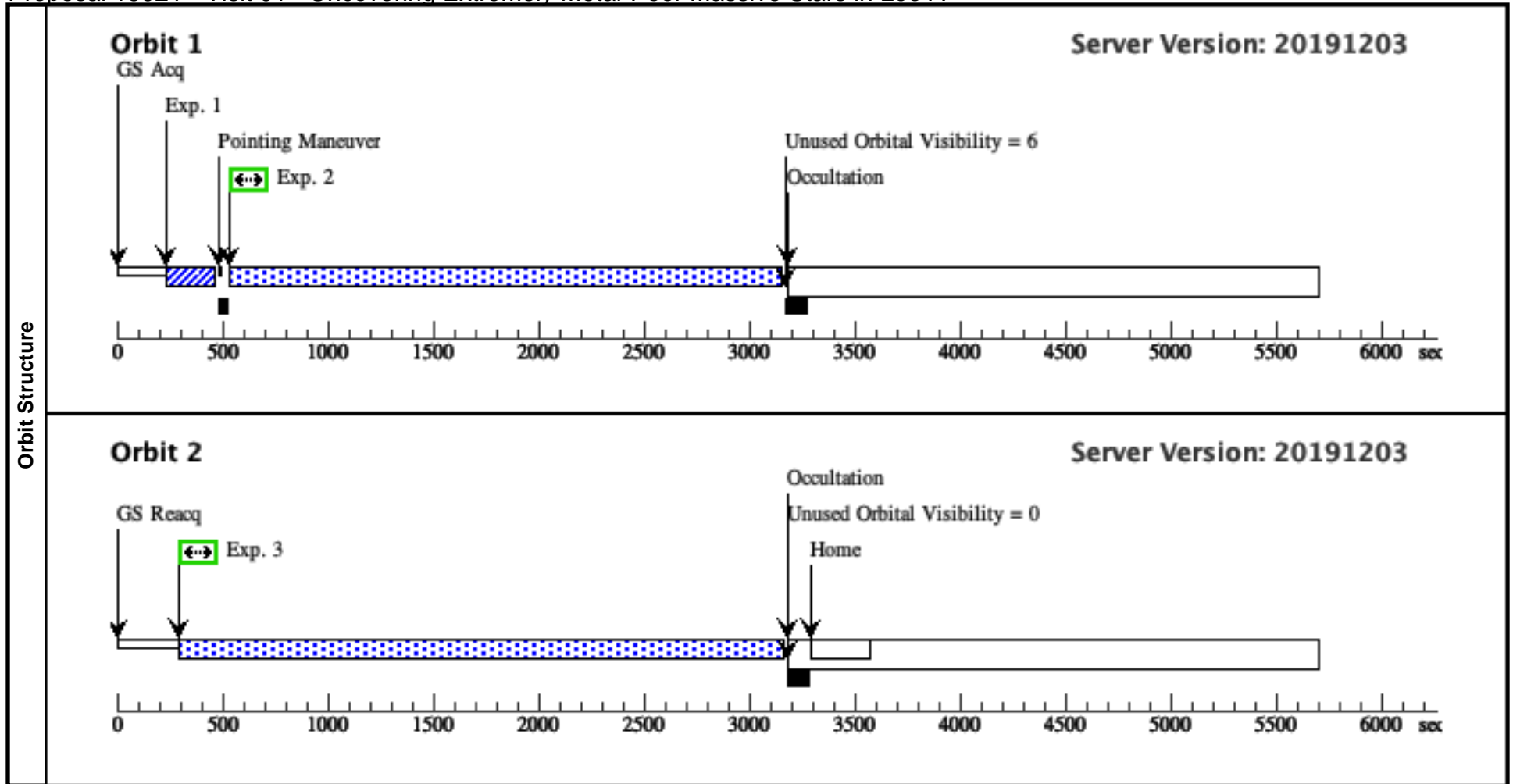
## Proposal 15921 (STScI Edit Number: 0, Created: Friday, May 1, 2020 at 9:00:25 AM Eastern Standard Time) - Overview

maximize the scheduling flexibility of our program, we split the 8-orbit integration time for each star into 4 visits of 2 orbits each. We will take spectroscopic exposures in TIME-TAG mode with each orbit devoted to a single FP-POS setting such that buffer readouts and grating shifts occur during target occultation. Although the estimated BUFFER-TIME required is larger than the exposure times, we set the BUFFER-TIME to the exposure time to ensure the entire buffer is read during occultation. We additionally swap the order of the FP-POS grating changes in subsequent visits to ensure each achieves the same amount of integration time. In 8 orbits per star, ETC estimates indicate that our required S/N of 20 per angstrom will be achieved for both stars, enabling confident measurement of both the stellar wind and photospheric features.

Proposal 15921 - Visit 01 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

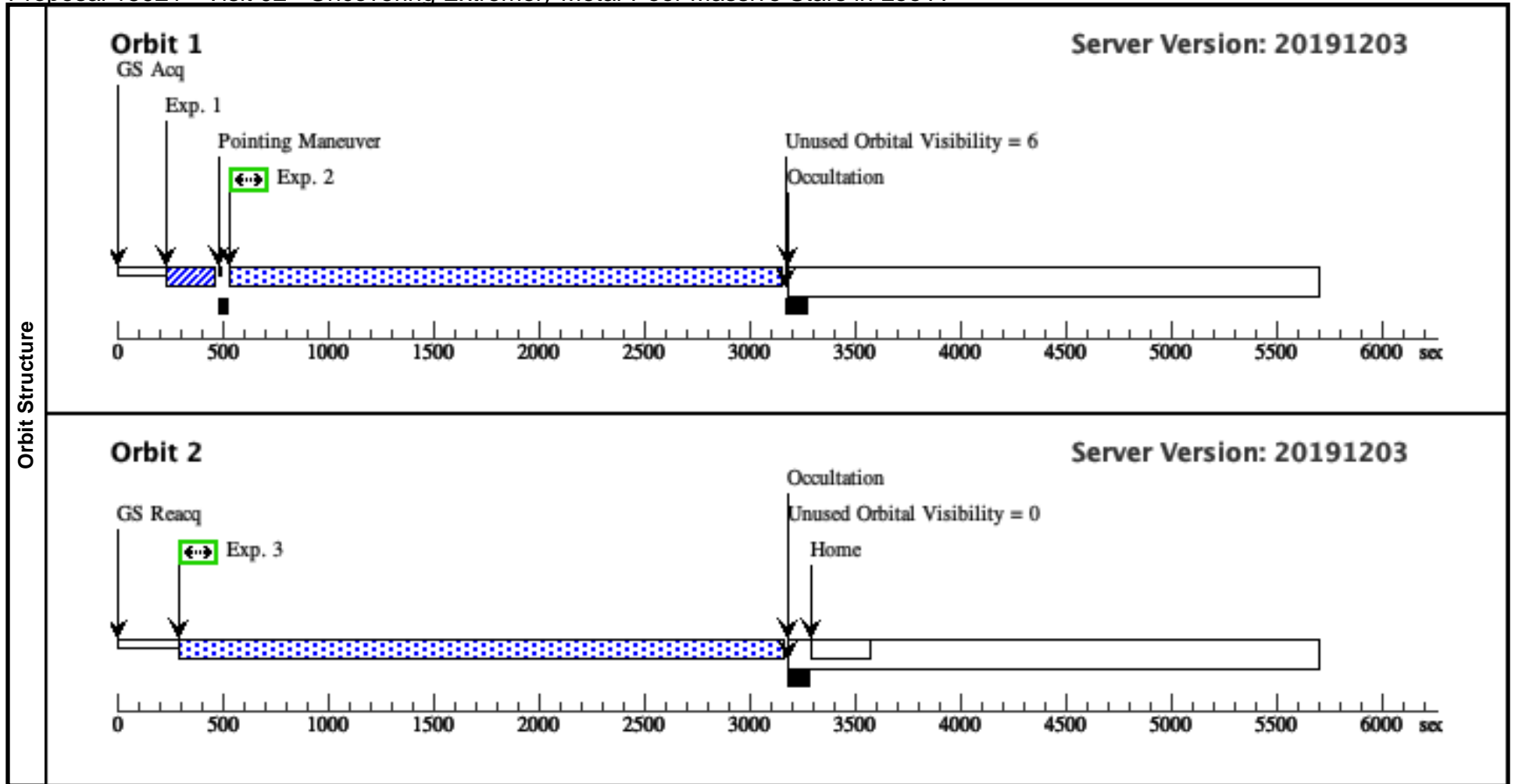
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		(1)	J095927.53+304457.7	RA: 09 59 27.5322 (149.8647175d) Dec: +30 44 57.78 (30.74938d) Equinox: J2000		V=20.1+/-0.1	Reference Frame: ICRS			
	<i>Comments:</i> Category=EXT-STAR Description=[MAIN SEQUENCE O] Extended=NO									
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	1	(COS.ta.136 8396)	(1) J095927.53+304 457.7	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs) [==>]	[1]
	2	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=1; BUFFER-TIME=2400			2400 Secs (2400 Secs) [==>]	[1]
	3	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=2; BUFFER-TIME=2814			2800 Secs (2814 Secs) [==>2814.0 Secs ]	[2]



Proposal 15921 - Visit 02 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

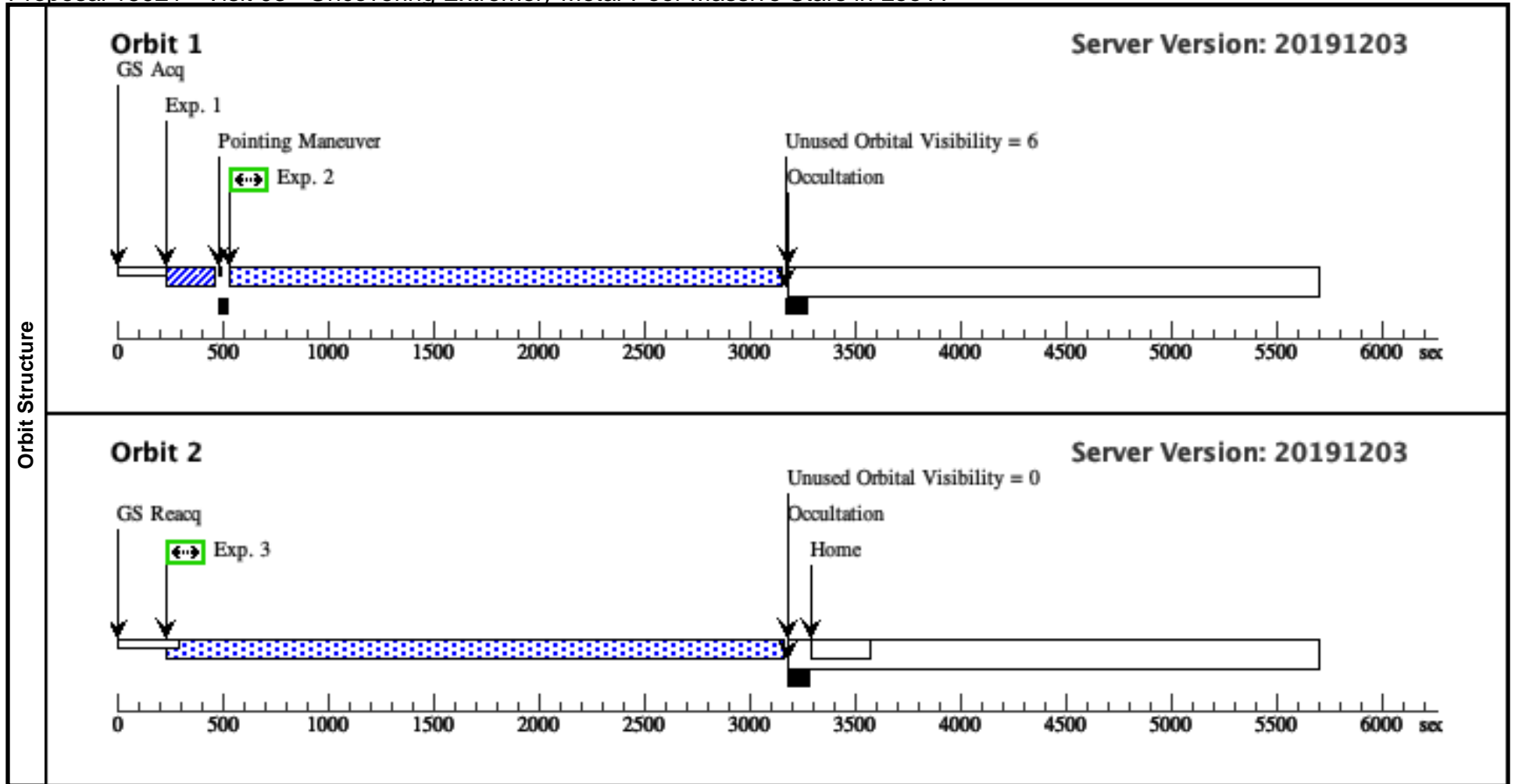
Visit	<b>Proposal 15921, Visit 02, scheduled</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: (none)									
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		(1)	J095927.53+304457.7	RA: 09 59 27.5322 (149.8647175d) Dec: +30 44 57.78 (30.74938d) Equinox: J2000		V=20.1+/-0.1	Reference Frame: ICRS			
	<i>Comments:</i> Category=EXT-STAR Description=[MAIN SEQUENCE O] 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.ta.136 8396)	(1) J095927.53+304 457.7	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs) [==>]	[1]
	2	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=3; BUFFER-TIME=2400			2400 Secs (2400 Secs) [==>]	[1]
	3	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=4; BUFFER-TIME=2814			2800 Secs (2814 Secs) [==>2814.0 Secs ]	[2]



Proposal 15921 - Visit 03 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

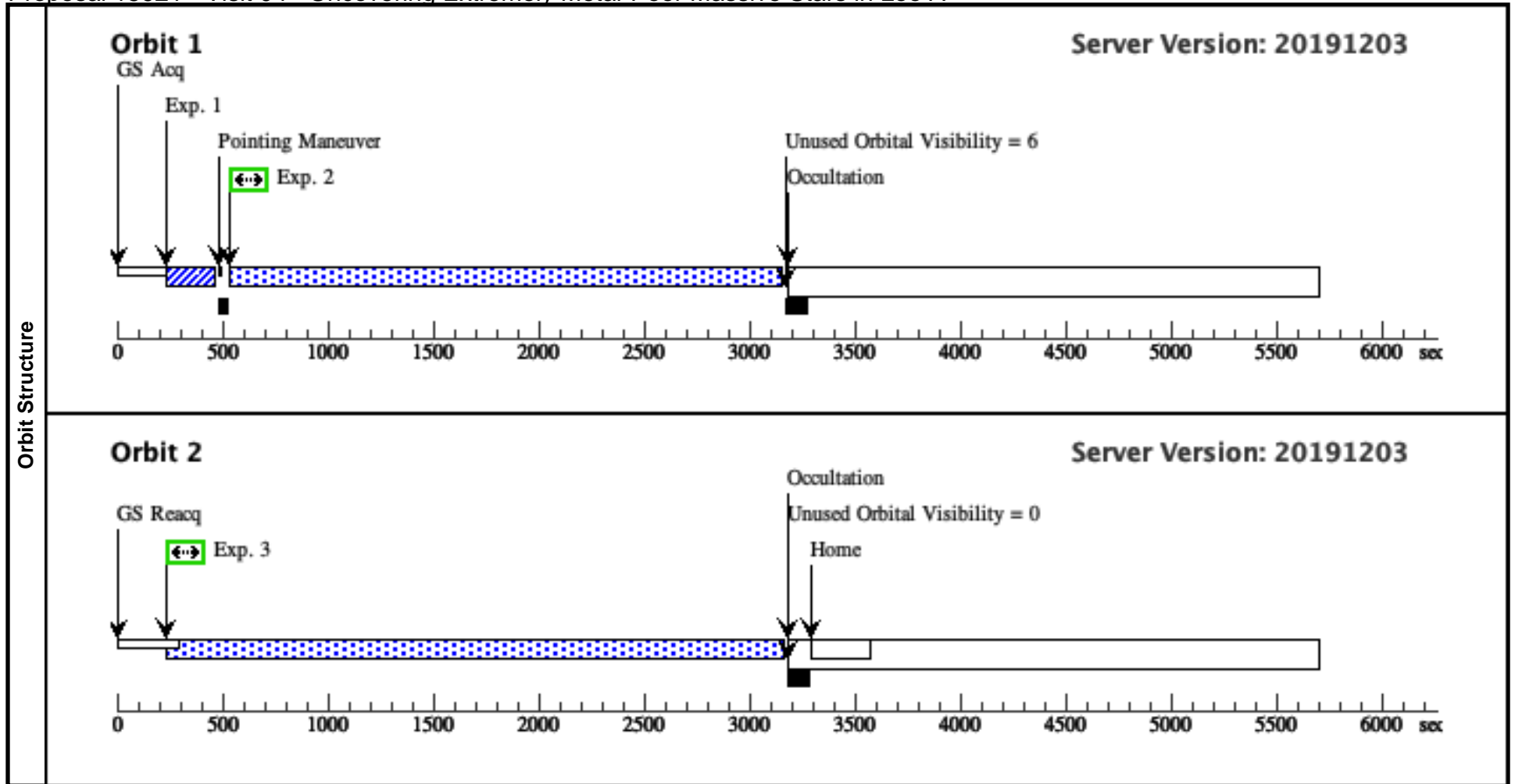
<b>Visit</b>	<b>Proposal 15921, Visit 03, failed</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: (none)																																																
	<b>Diagnosics</b> (Visit 03) Warning (Orbit Planner): INEFFICIENT ORDERING OF FP-POS POSITIONS																																																
<b>Fixed Targets</b>	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>J095927.53+304457.7</td> <td>RA: 09 59 27.5322 (149.8647175d) Dec: +30 44 57.78 (30.74938d) Equinox: J2000</td> <td></td> <td>V=20.1+/-0.1</td> <td>Reference Frame: ICRS</td> </tr> </tbody> </table> <p><i>Comments:</i>                  Category=EXT-STAR                  Description=[MAIN SEQUENCE O]                  Extended=NO</p>										#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(1)	J095927.53+304457.7	RA: 09 59 27.5322 (149.8647175d) Dec: +30 44 57.78 (30.74938d) Equinox: J2000		V=20.1+/-0.1	Reference Frame: ICRS																											
	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous																																											
(1)	J095927.53+304457.7	RA: 09 59 27.5322 (149.8647175d) Dec: +30 44 57.78 (30.74938d) Equinox: J2000		V=20.1+/-0.1	Reference Frame: ICRS																																												
<table border="1"> <thead> <tr> <th>#</th> <th>Label (ETC Run)</th> <th>Target</th> <th>Config,Mode,Aperture</th> <th>Spectral Els.</th> <th>Opt. Params.</th> <th>Special Reqs.</th> <th>Groups</th> <th>Exp. Time (Total)/[Actual Dur.]</th> <th>Orbit</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>(COS.ta.136 8396)</td> <td>(1) J095927.53+304 457.7</td> <td>COS/NUV, ACQ/IMAGE, PSA</td> <td>MIRRORA</td> <td></td> <td></td> <td></td> <td>8 Secs (8 Secs) [==&gt;]</td> <td>[1]</td> </tr> <tr> <td>2</td> <td>(COS.sp.137 1853)</td> <td>(1) J095927.53+304 457.7</td> <td>COS/FUV, TIME-TAG, PSA</td> <td>G160M 1533 A</td> <td>FLASH=YES; FP-POS=2; BUFFER-TIME=24 00</td> <td></td> <td></td> <td>2400 Secs (2400 Secs) [==&gt;]</td> <td>[1]</td> </tr> <tr> <td>3</td> <td>(COS.sp.137 1853)</td> <td>(1) J095927.53+304 457.7</td> <td>COS/FUV, TIME-TAG, PSA</td> <td>G160M 1533 A</td> <td>FLASH=YES; FP-POS=1; BUFFER-TIME=28 14</td> <td></td> <td></td> <td>2800 Secs (2814 Secs) [==&gt;2814.0 Secs ]</td> <td>[2]</td> </tr> </tbody> </table>										#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit	1	(COS.ta.136 8396)	(1) J095927.53+304 457.7	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs) [==>]	[1]	2	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=2; BUFFER-TIME=24 00			2400 Secs (2400 Secs) [==>]	[1]	3	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=1; BUFFER-TIME=28 14			2800 Secs (2814 Secs) [==>2814.0 Secs ]	[2]
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit																																								
1	(COS.ta.136 8396)	(1) J095927.53+304 457.7	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs) [==>]	[1]																																								
2	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=2; BUFFER-TIME=24 00			2400 Secs (2400 Secs) [==>]	[1]																																								
3	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=1; BUFFER-TIME=28 14			2800 Secs (2814 Secs) [==>2814.0 Secs ]	[2]																																								



Proposal 15921 - Visit 04 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

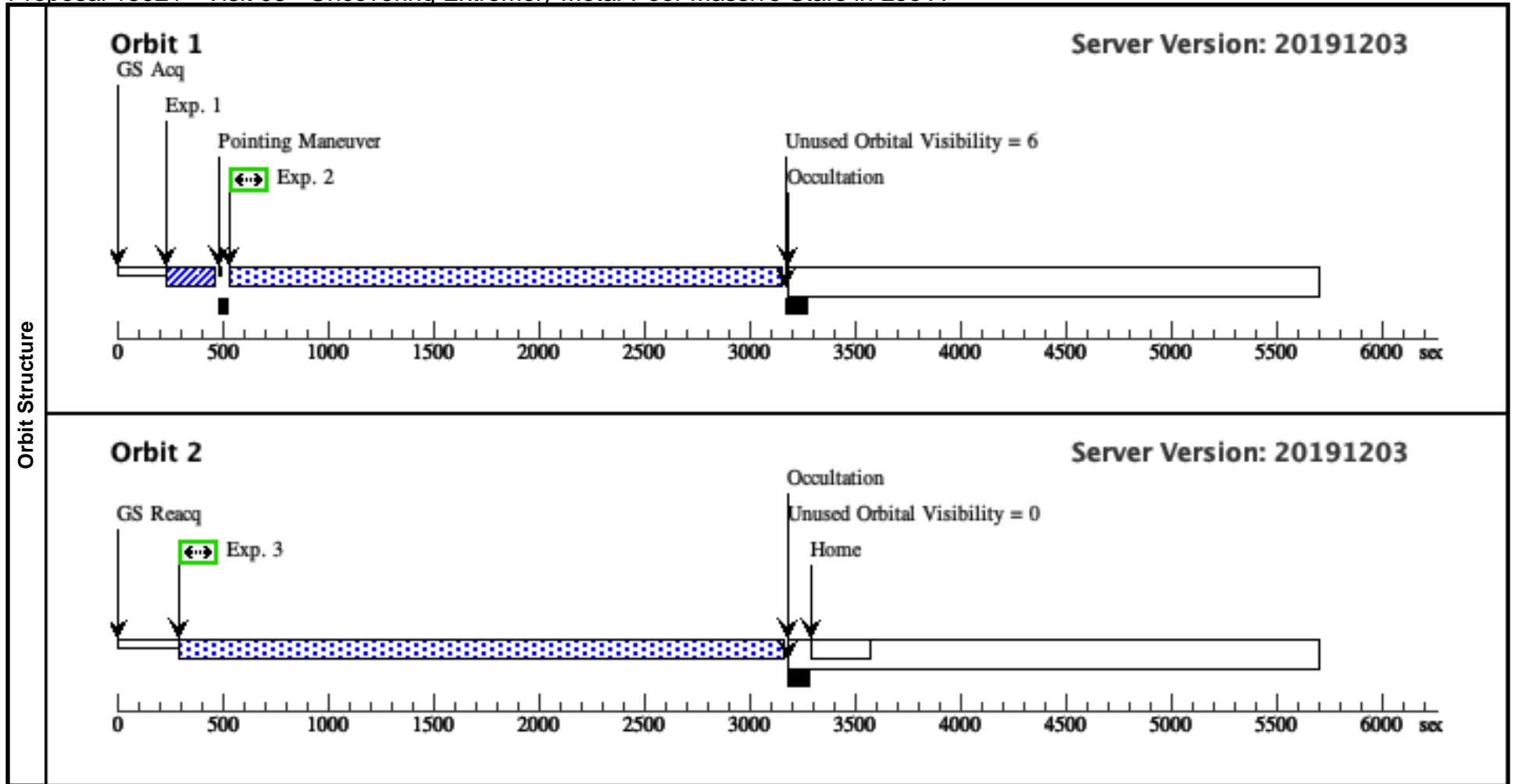
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	(Visit 04) Warning (Orbit Planner): INEFFICIENT ORDERING OF FP-POS POSITIONS									
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>	<b>Fluxes</b>	<b>Miscellaneous</b>				
	(1)	J095927.53+304457.7	RA: 09 59 27.5322 (149.8647175d) Dec: +30 44 57.78 (30.74938d) Equinox: J2000		V=20.1+/-0.1	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[MAIN SEQUENCE O] Extended=NO										
<b>Exposures</b>	<b>#</b>	<b>Label (ETC Run)</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(COS.ta.136 8396)	(1) J095927.53+304 457.7	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs)	
									[==>]	[1]
	2	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=4; BUFFER-TIME=24 00			2400 Secs (2400 Secs)	
								[==>]	[1]	
3	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=3; BUFFER-TIME=28 14			2800 Secs (2814 Secs)		
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Proposal 15921 - Visit 05 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

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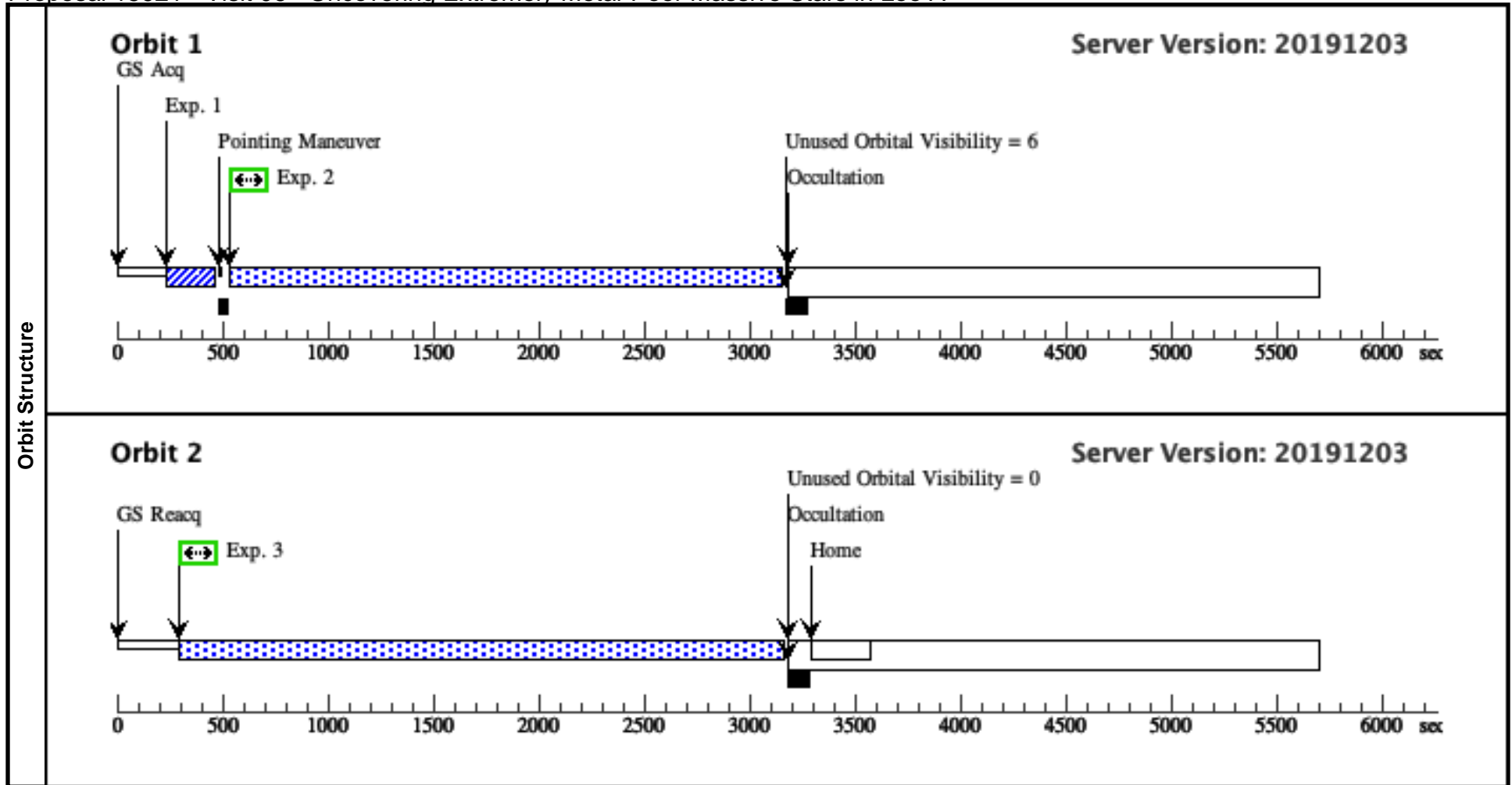
Visit	<b>Proposal 15921, Visit 05, scheduled</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: (none)									
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		(2)	J095930.22+304437.0	RA: 09 59 30.2299 (149.8759579d) Dec: +30 44 37.07 (30.74363d) Equinox: J2000		V=20.2+/-0.1	Reference Frame: ICRS			
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Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(COS.ta.136 8396)	(2) J095930.22+304 437.0	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs) [==>]	[1]
	2	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=1; BUFFER-TIME=2400			2400 Secs (2400 Secs) [==>]	[1]
	3	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=2; BUFFER-TIME=2814			2800 Secs (2814 Secs) [==>2814.0 Secs ]	[2]



Proposal 15921 - Visit 06 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

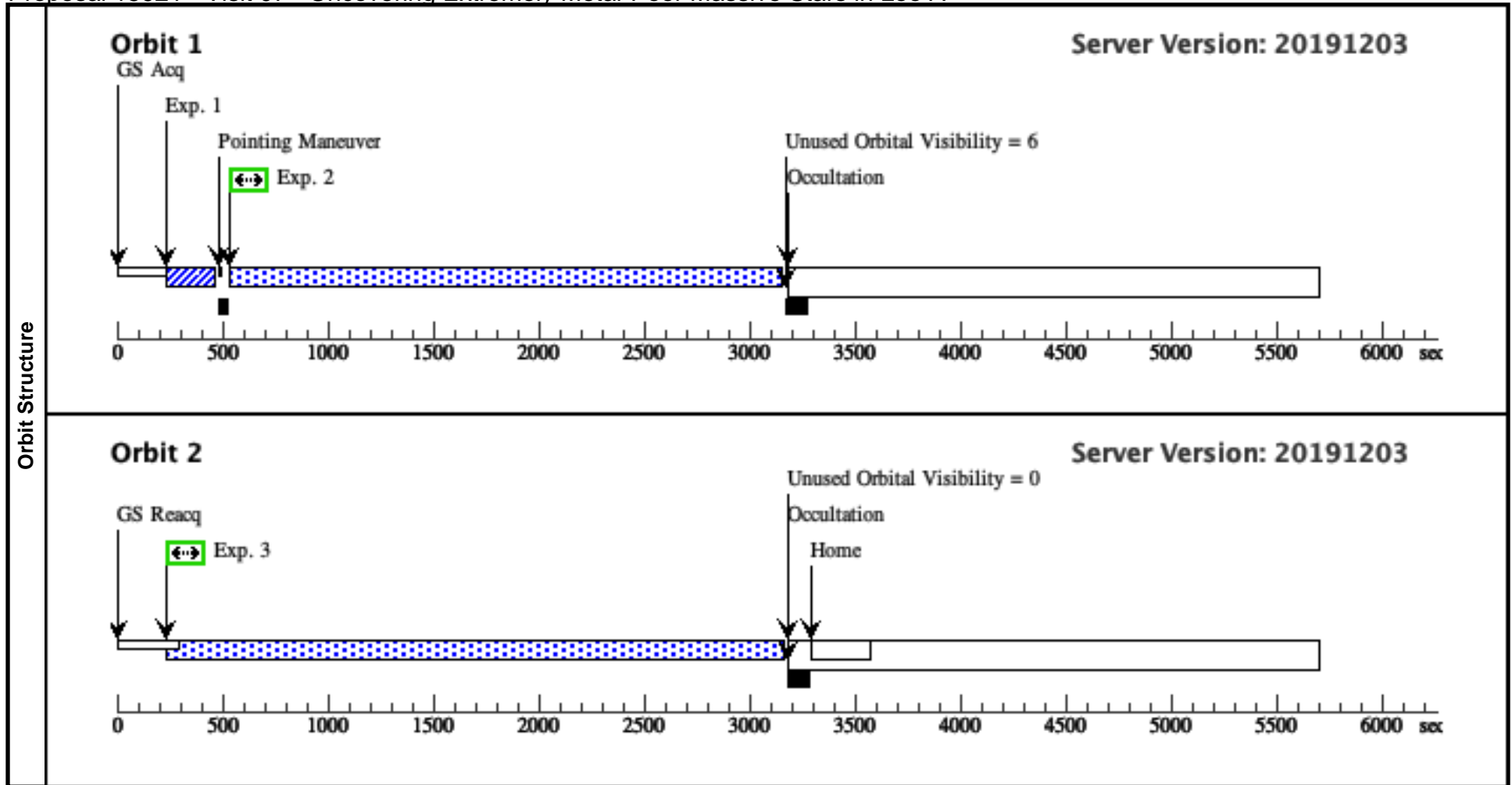
Visit	<b>Proposal 15921, Visit 06, completed</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: (none)									
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		(2)	J095930.22+304437.0	RA: 09 59 30.2299 (149.8759579d) Dec: +30 44 37.07 (30.74363d) Equinox: J2000		V=20.2+/-0.1	Reference Frame: ICRS			
	<i>Comments:</i> Category=EXT-STAR Description=[MAIN SEQUENCE O] 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.ta.136 8396)	(2) J095930.22+304 437.0	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs) [==>]	[1]
	2	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=3; BUFFER-TIME=2400			2400 Secs (2400 Secs) [==>]	[1]
	3	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=4; BUFFER-TIME=2814			2800 Secs (2814 Secs) [==>2814.0 Secs ]	[2]



Proposal 15921 - Visit 07 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

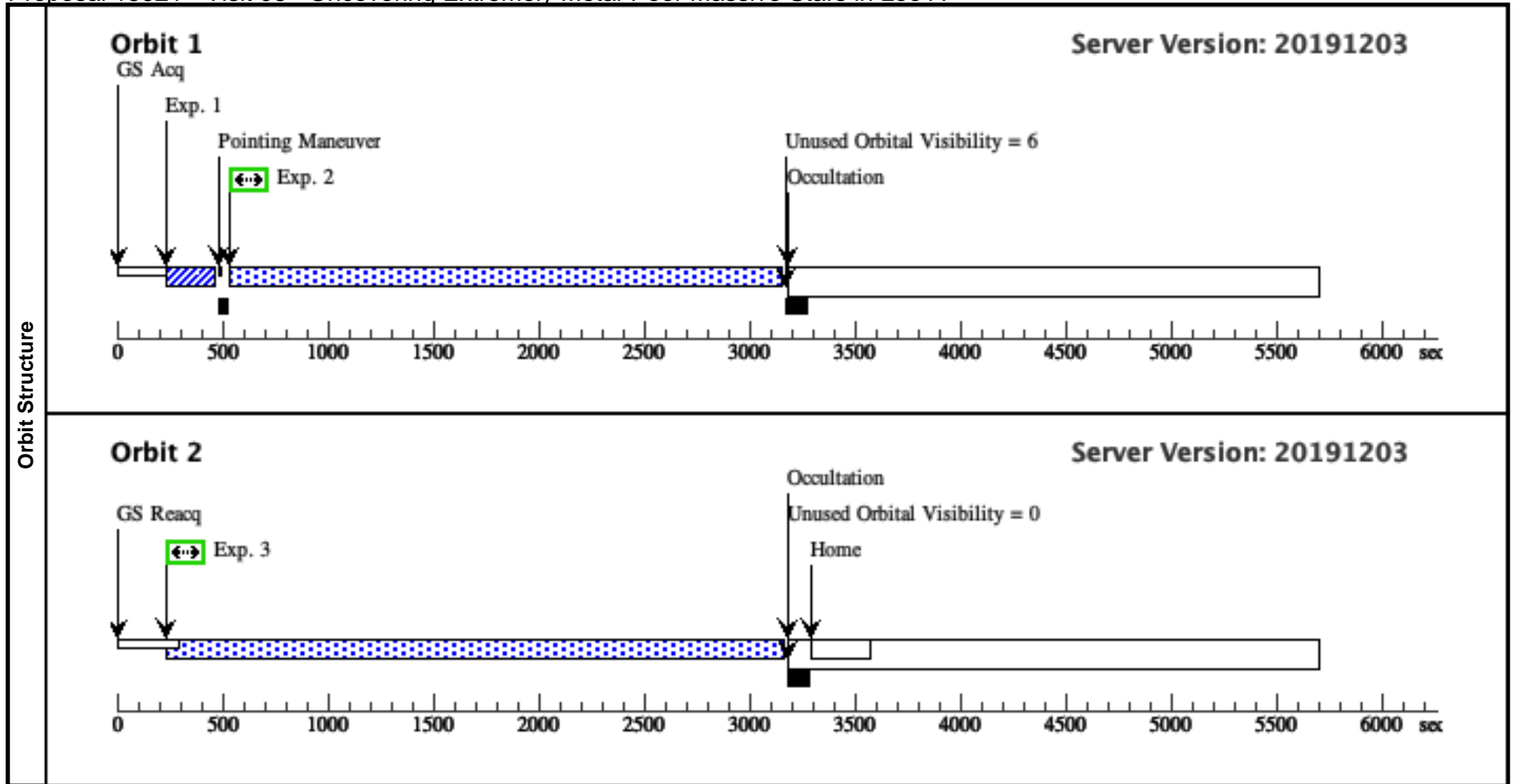
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<b>Fixed Targets</b>	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(2)	J095930.22+304437.0	RA: 09 59 30.2299 (149.8759579d) Dec: +30 44 37.07 (30.74363d) Equinox: J2000		V=20.2+/-0.1	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[MAIN SEQUENCE O] Extended=NO										
<b>Exposures</b>	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(COS.ta.136 8396)	(2) J095930.22+304 437.0	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs)	
									[==>]	[1]
	2	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=2; BUFFER-TIME=24 00			2400 Secs (2400 Secs)	
								[==>]	[1]	
3	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=1; BUFFER-TIME=28 14			2800 Secs (2814 Secs)		
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Proposal 15921 - Visit 08 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

<b>Visit</b>	<b>Proposal 15921, Visit 08, completed</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: (none)									
	(Visit 08) Warning (Orbit Planner): INEFFICIENT ORDERING OF FP-POS POSITIONS									
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>	<b>Fluxes</b>	<b>Miscellaneous</b>				
	(2)	J095930.22+304437.0	RA: 09 59 30.2299 (149.8759579d) Dec: +30 44 37.07 (30.74363d) Equinox: J2000		V=20.2+/-0.1	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[MAIN SEQUENCE O] Extended=NO										
<b>Exposures</b>	<b>#</b>	<b>Label (ETC Run)</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(COS.ta.136 8396)	(2) J095930.22+304 437.0	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs)	
									[==>]	[1]
	2	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=4; BUFFER-TIME=24 00			2400 Secs (2400 Secs)	
								[==>]	[1]	
3	(COS.sp.137 1851)	(2) J095930.22+304 437.0	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=3; BUFFER-TIME=28 14			2800 Secs (2814 Secs)		
								[==>2814.0 Secs ]	[2]	



Proposal 15921 - Visit 23 - Uncovering Extremely Metal-Poor Massive Stars in Leo A

Fri May 01 14:00:25 GMT 2020

<b>Visit</b>	<b>Proposal 15921, Visit 23</b>				
	<b>Diagnostic Status: No Diagnostics</b>				
	Scientific Instruments: COS/FUV, COS/NUV				
	Special Requirements: (none)				

<b>Fixed Targets</b>	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	J095927.53+304457.7	RA: 09 59 27.5322 (149.8647175d) Dec: +30 44 57.78 (30.74938d) Equinox: J2000		V=20.1+/-0.1	Reference Frame: ICRS
	<i>Comments:</i>					
	Category=EXT-STAR Description=[MAIN SEQUENCE O] Extended=NO					

<b>Exposures</b>	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(COS.ta.136 8396)	(1) J095927.53+304 457.7	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				8 Secs (8 Secs) [==>]	[1]
	2	(COS.sp.137 1853)	(1) J095927.53+304 457.7	COS/FUV, TIME-TAG, PSA	G160M 1533 A	FLASH=YES; FP-POS=2; BUFFER-TIME=24 00			2400 Secs (2400 Secs) [==>]	[1]

