



# 11782 - Measuring the Shape and Orientation of the Galactic Dark-Matter Halo using Hypervelocity Stars

Cycle: 17, Proposal Category: GO

(Availability Mode: SUPPORTED)

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
<b>Dr. Oleg Y. Gnedin (PI)</b>	<b>The Ohio State University Research Foundation</b>	<b>ognedin@astronomy.ohio-state.edu</b>
Dr. Andrew Gould (CoI)	The Ohio State University Research Foundation	gould@astronomy.ohio-state.edu
Mr. Jose Luis Prieto (CoI)	The Ohio State University Research Foundation	prieto@astronomy.ohio-state.edu
Dr. Krzysztof Stanek (CoI)	The Ohio State University Research Foundation	kstanek@astronomy.ohio-state.edu
Dr. Howard E. Bond (CoI)	Space Telescope Science Institute	bond@stsci.edu
Dr. Mario Livio (CoI)	Space Telescope Science Institute	mlivio@stsci.edu
Dr. Edmund Nelan (CoI)	Space Telescope Science Institute	nelan@stsci.edu
Dr. Warren R. Brown (CoI)	Smithsonian Institution Astrophysical Observatory	wbrown@cfa.harvard.edu
Dr. Margaret Geller (CoI)	Smithsonian Institution Astrophysical Observatory	mjg@cfa.harvard.edu
Dr. Scott J. Kenyon (CoI)	Smithsonian Institution Astrophysical Observatory	kenyon@cfa.harvard.edu
Dr. Michael J. Kurtz (CoI)	Smithsonian Institution Astrophysical Observatory	mkurtz@cfa.harvard.edu
Dr. Jay Anderson (CoI)	Space Telescope Science Institute	jayander@stsci.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) SDSSJ090745.0+024507	ACS/WFC	1	26-Aug-2009 21:10:34.0	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>
02	(2) SDSSJ093320.86+441705.4	ACS/WFC	1	26-Aug-2009 21:10:38.0	yes
03	(3) HE0437-5439	ACS/WFC	1	26-Aug-2009 21:10:42.0	yes
04	(4) SDSSJ091301.0+305120	ACS/WFC	1	26-Aug-2009 21:10:46.0	yes
05	(5) SDSSJ091759.5+672238	ACS/WFC	1	26-Aug-2009 21:10:50.0	yes

5 Total Orbits Used

### **ABSTRACT**

We propose to obtain high-resolution images of five hypervelocity stars in the Galactic halo in order to establish the first-epoch astrometric frame for them, as a part of a long-term program to measure precise proper motions. The origin of these recently discovered stars, all with positive radial velocities above 540 km/s, is consistent only with being ejected from the deep potential well of the massive black hole at the Galactic center. The deviations of their space motions from purely radial trajectories probe the departures from spherical symmetry of the Galactic potential, mainly due to the triaxiality of the dark-matter halo. Reconstructing the full three-dimensional space motion of the hypervelocity stars, through astrometric proper motions, provides a unique opportunity to measure the shape and orientation of the dark halo. The hypervelocity stars allow measurement of the potential up to 75 kpc from the center, independently of and at larger distances than are afforded by tidal streams of satellite galaxies such as the Sagittarius dSph galaxy. HVS3 may be associated with the LMC, rather than the Galactic center, and would therefore present a case for a supermassive black hole at the center of the LMC. We request one orbit with ACS/WFC for each of the five hypervelocity stars to establish their current positions relative to background galaxies. We will request a repeated observation of these stars in Cycle 17, which will conclusively measure the astrometric proper motions.

### **OBSERVING DESCRIPTION**

In this program we are obtaining second-epoch images of 5 hypervelocity stars. The aim is to measure their proper motions against the reference frame of background galaxies.

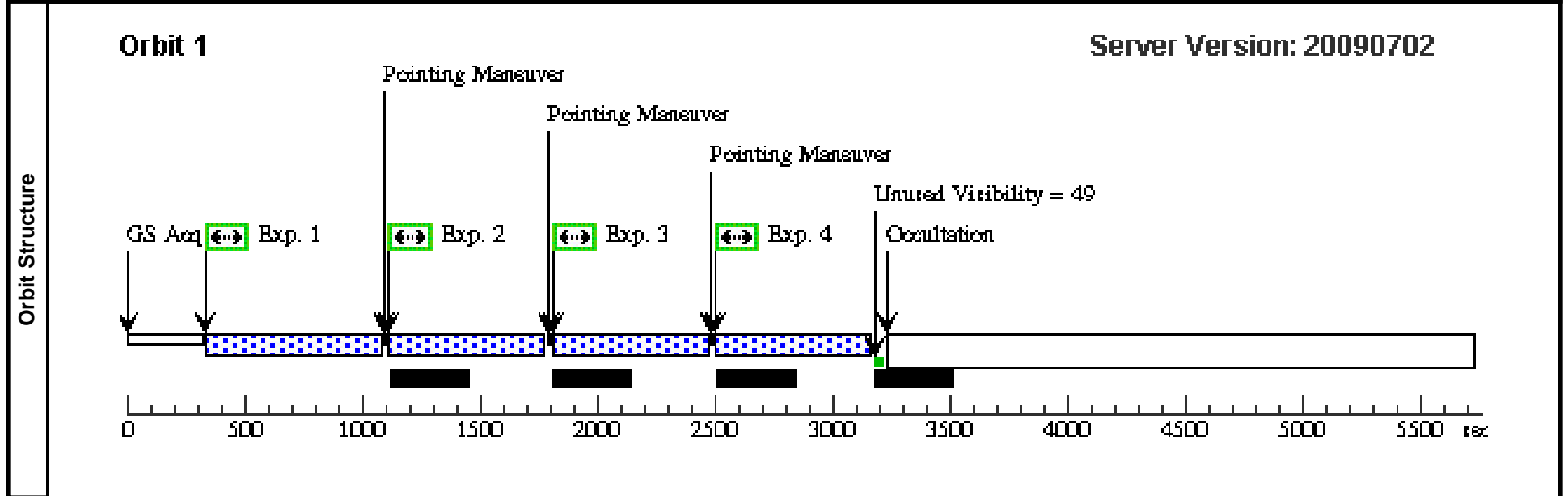
Each target will be centered either in the middle of WFC1, or for the brightest targets we will reduce overheads by using the subraster WFC1-2K. The targets will be observed either in F814W or F850LP, which appear to be better filters than the F606W mentioned in the original proposal. The reason is that the crucial background galaxies will give a better S/N at longer wavelengths, according to the ACS ETC. For each target we will take the maximum number of exposures possible in one orbit, with appropriate dithering. Exposures are chosen for each target to be no more than 70% of saturation on the target star.

For these second-epoch observations, we are specifying the exact same ORIENT's that were used for the first-epoch observations in Cycle 15.

<b>Visit</b>	<b>Proposal 11782, Visit 01, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: ACS/WFC Special Requirements: ORIENT 279.7631D TO 279.7631 D; BEFORE 17-OCT-2009:00:00:00 Comments: <i>The ORIENT is chosen to exactly duplicate that used in the first-epoch observations made in Cycle 15.</i>				

<b>Fixed Targets</b>	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	SDSSJ090745.0+024507 Alt Name1: HVS1	RA: 09 07 44.9900 (136.9374583d) Dec: +02 45 6.40 (2.75178d) Equinox: J2000		V=19.96+/-0.2	Reference Frame: ICRS

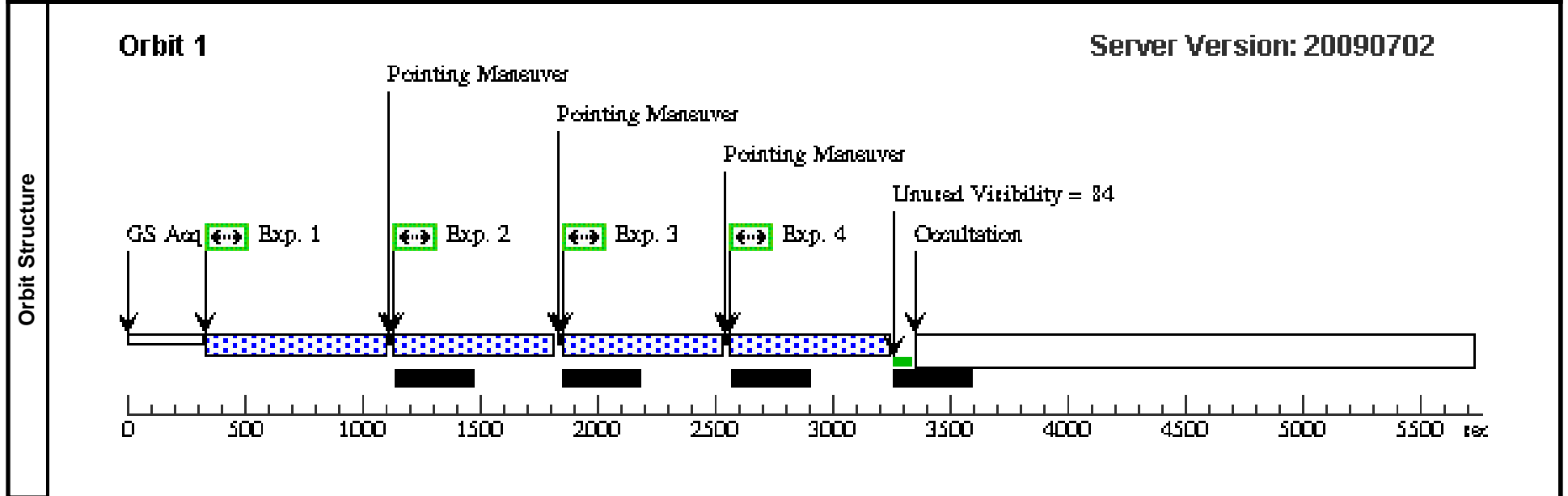
<b>Exposures</b>	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(1) SDSSJ090745.0+024507	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	GS ACQ SCENARI O BASE1B3		540.0 Secs [==>]	[1]
	2		(1) SDSSJ090745.0+024507	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.25073, 0.54151		540.0 Secs [==>]	[1]
	3		(1) SDSSJ090745.0+024507	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.52487, 0.7861		540.0 Secs [==>]	[1]
	4		(1) SDSSJ090745.0+024507	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.7713,0 .33176		540.0 Secs [==>]	[1]



<b>Visit</b>	<b>Proposal 11782, Visit 02, implementation</b>				
	<b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: ACS/WFC Special Requirements: ORIENT 303.7515D TO 303.7515 D; BEFORE 09-NOV-2009:00:00:00 <i>Comments: The ORIENT is chosen to exactly duplicate that used in the first-epoch observations made in Cycle 15.</i>				

<b>Fixed Targets</b>	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(2)	SDSSJ093320.86+441705.4 Alt Name1: HVS2 Alt Name2: US708	RA: 09 33 20.8800 (143.3370000d) Dec: +44 17 5.50 (44.28486d) Equinox: J2000		V=19+/-0.2	Reference Frame: ICRS

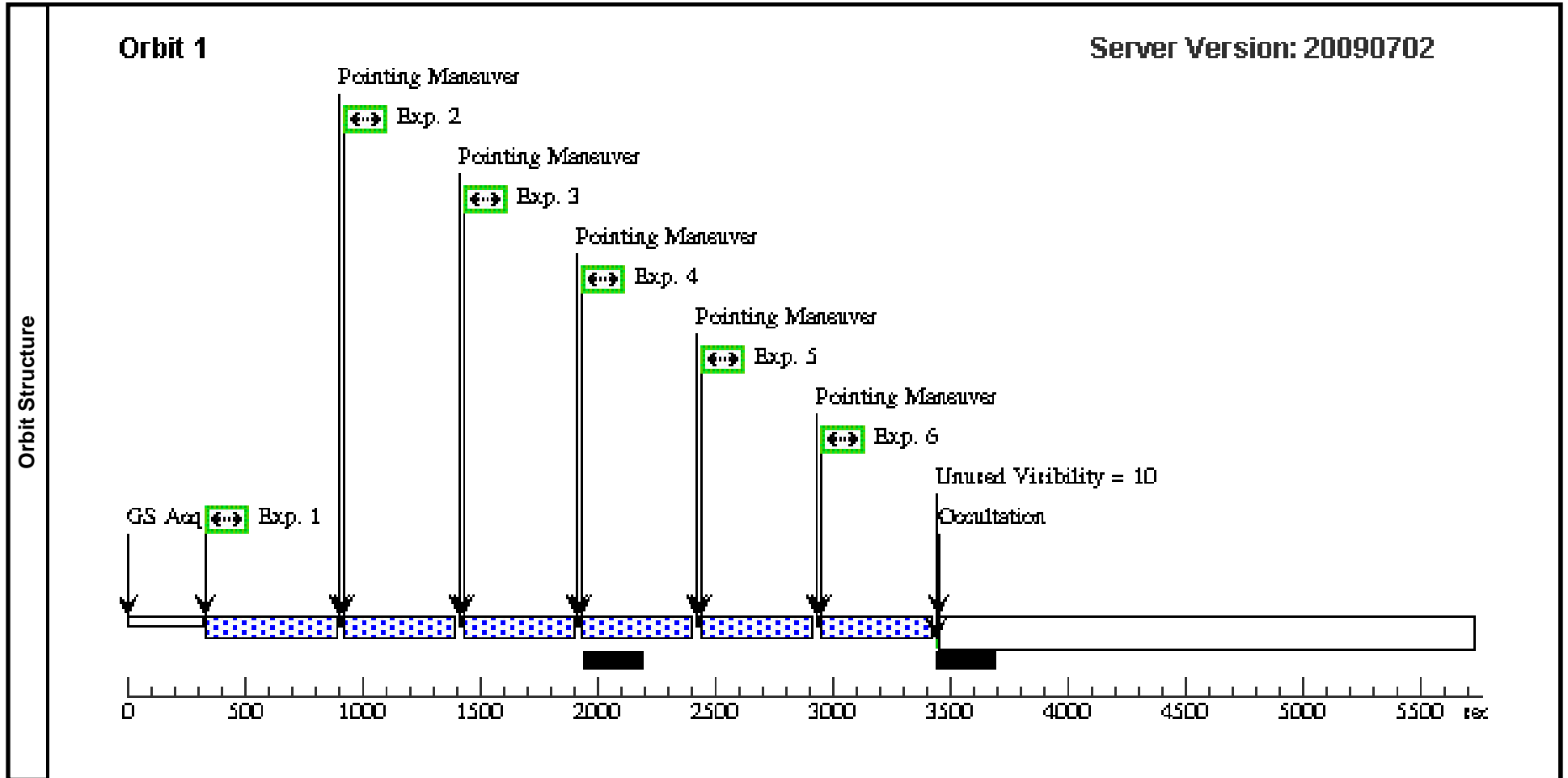
<b>Exposures</b>	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(2) SDSSJ093320.86+441705.4	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	GS ACQ SCENARI O BASE1B3		560.0 Secs [==>]	[1]
	2		(2) SDSSJ093320.86+441705.4	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.25073, 0.54151		560.0 Secs [==>]	[1]
	3		(2) SDSSJ093320.86+441705.4	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.52487, 0.7861		560.0 Secs [==>]	[1]
	4		(2) SDSSJ093320.86+441705.4	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.7713,0 .33176		560.0 Secs [==>]	[1]



Proposal 11782 - Visit 03 - Measuring the Shape and Orientation of the Galactic Dark-Matter Halo using Hypervelocity ...

Thu Aug 27 01:10:55 GMT 2009

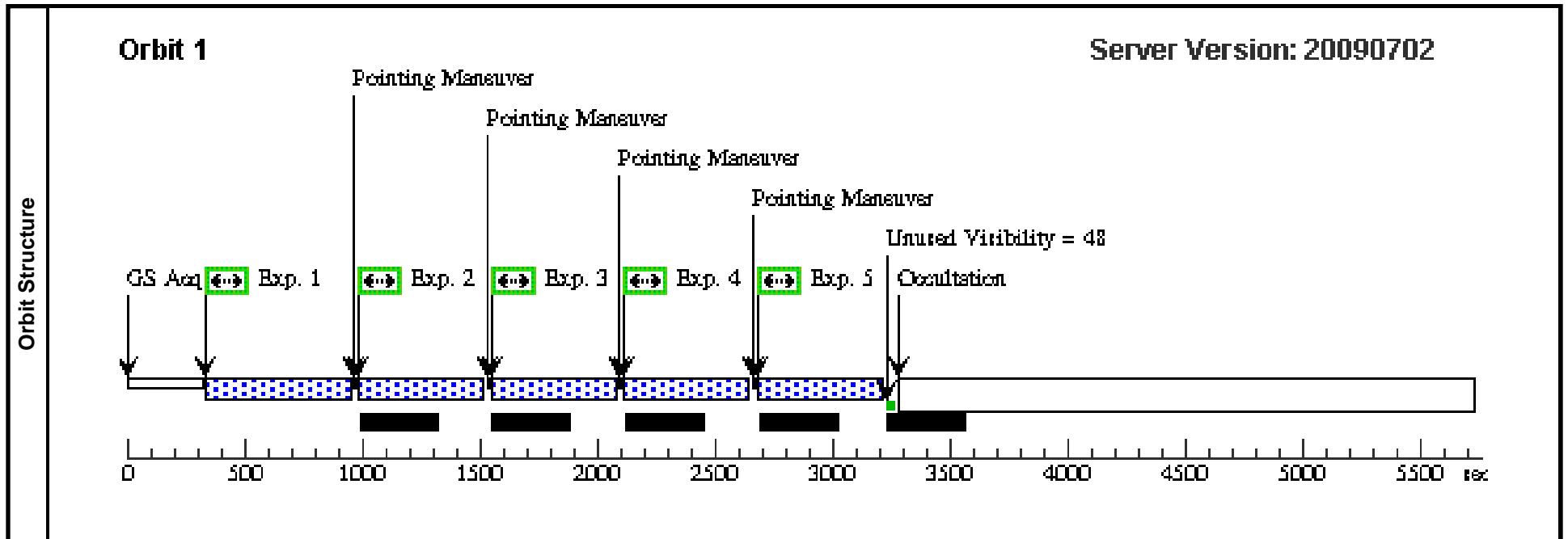
Visit	<b>Proposal 11782, Visit 03, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: ACS/WFC Special Requirements: ORIENT 34.9785D TO 34.9785 D; BEFORE 28-DEC-2009:00:00:00 Comments: <i>The ORIENT is chosen to exactly duplicate that used in the first-epoch observations made in Cycle 15.</i>									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
	(3)	HE0437-5439 Alt Name1: HVS3	RA: 04 38 12.7700 (69.5532083d) Dec: -54 33 11.80 (-54.55328d) Equinox: J2000			V=16.2+/-0.2	Reference Frame: ICRS			
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(3) HE0437-5439	ACS/WFC, ACCUM, WFC1-2K	F850LP	CR-SPLIT=NO			300 Secs [==>]	[1]
	2		(3) HE0437-5439	ACS/WFC, ACCUM, WFC1-2K	F850LP	CR-SPLIT=NO	POS TARG 0.29815, 0.0473		300 Secs [==>]	[1]
	3		(3) HE0437-5439	ACS/WFC, ACCUM, WFC1-2K	F850LP	CR-SPLIT=NO	POS TARG 0.6127,0 .04604		300 Secs [==>]	[1]
	4		(3) HE0437-5439	ACS/WFC, ACCUM, WFC1-2K	F850LP	CR-SPLIT=NO	POS TARG 0.16794, 0.53528		300 Secs [==>]	[1]
	5		(3) HE0437-5439	ACS/WFC, ACCUM, WFC1-2K	F850LP	CR-SPLIT=NO	POS TARG 0.48231 00000000007,0.534 04		300 Secs [==>]	[1]
	6		(3) HE0437-5439	ACS/WFC, ACCUM, WFC1-2K	F850LP	CR-SPLIT=NO	POS TARG 0.78064, 0.58136		300 Secs [==>]	[1]



Proposal 11782 - Visit 04 - Measuring the Shape and Orientation of the Galactic Dark-Matter Halo using Hypervelocity ...

Thu Aug 27 01:10:56 GMT 2009

Visit	<b>Proposal 11782, Visit 04, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: ACS/WFC Special Requirements: ORIENT 276.68D TO 277.9537 D; BEFORE 10-NOV-2009:00:00:00 Comments: <i>The ORIENT is chosen to exactly duplicate that used in the first-epoch observations made in Cycle 15.</i>									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
	(4)	SDSSJ091301.0+305120 Alt Name1: HVS4	RA: 09 13 1.0000 (138.2541667d) Dec: +30 51 20.20 (30.85561d) Equinox: J2000		V=18.59+/-0.2	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(4) SDSSJ091301.0+305120	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	GS ACQ SCENARI O BASE1B3		410.0 Secs [==>]	[1]
2		(4) SDSSJ091301.0+305120	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.26063, 0.53727		410.0 Secs [==>]	[1]	
3		(4) SDSSJ091301.0+305120	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.5212,1 .07448		410.0 Secs [==>]	[1]	
4		(4) SDSSJ091301.0+305120	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 0.77839, 0.81512		410.0 Secs [==>]	[1]	
5		(4) SDSSJ091301.0+305120	ACS/WFC, ACCUM, WFC1	F814W	CR-SPLIT=NO	POS TARG 1.03448, 0.35651		410.0 Secs [==>]	[1]	



Proposal 11782 - Visit 05 - Measuring the Shape and Orientation of the Galactic Dark-Matter Halo using Hypervelocity ...

Thu Aug 27 01:10:57 GMT 2009

Visit	<b>Proposal 11782, Visit 05, scheduling</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: ACS/WFC Special Requirements: ORIENT 336.2947D TO 336.2947 D; BEFORE 06-SEP-2009:00:00:00 Comments: <i>The ORIENT is chosen to exactly duplicate that used in the first-epoch observations made in Cycle 15.</i>									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
	(5)	SDSSJ091759.5+672238 Alt Name1: HVS5	RA: 09 17 59.5500 (139.4981250d) Dec: +67 22 38.80 (67.37744d) Equinox: J2000		V=18.09+/-0.2	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(5) SDSSJ091759.5+672238	ACS/WFC, ACCUM, WFC1-2K	F814W	CR-SPLIT=NO			200.0 Secs [==>]	[1]
	2		(5) SDSSJ091759.5+672238	ACS/WFC, ACCUM, WFC1-2K	F814W	CR-SPLIT=NO	POS TARG 0.30527, 0.05137		200.0 Secs [==>]	[1]
	3		(5) SDSSJ091759.5+672238	ACS/WFC, ACCUM, WFC1-2K	F814W	CR-SPLIT=NO	POS TARG 0.6104,0.05299		200.0 Secs [==>]	[1]
	4		(5) SDSSJ091759.5+672238	ACS/WFC, ACCUM, WFC1-2K	F814W	CR-SPLIT=NO	POS TARG 0.1727,0.5321		200.0 Secs [==>]	[1]
	5		(5) SDSSJ091759.5+672238	ACS/WFC, ACCUM, WFC1-2K	F814W	CR-SPLIT=NO	POS TARG 0.47775, 0.56923		200.0 Secs [==>]	[1]
	6		(5) SDSSJ091759.5+672238	ACS/WFC, ACCUM, WFC1-2K	F814W	CR-SPLIT=NO	POS TARG 0.7831,0.59932		200.0 Secs [==>]	[1]
	7		(5) SDSSJ091759.5+672238	ACS/WFC, ACCUM, WFC1-2K	F814W	CR-SPLIT=NO	POS TARG 0.93792, 0.33363		200.0 Secs [==>]	[1]

