12274 - Proper motion study of M54: an intermediate-mass black hole in the nucleus of the Sagittarius Dwarf Galaxy?

Cycle: 18, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Roeland P. van der Marel (PI)	**Space Telescope Science Institute**	**marel@stsci.edu**
Dr. Jay Anderson (CoI)	Space Telescope Science Institute	jayander@stsci.edu
Dr. Rodrigo Ibata (CoI) (ESA Member)	Universite de Strasbourg I	ibata@newb6.u-strasbg.fr

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) M54	WFC3/UVIS	2	23-Aug-2011 01:15:53.0	yes

2 Total Orbits Used

ABSTRACT

Intermediate Mass Black Holes (IMBHs) are objects of considerable astrophysical significance, and the centers of globular clusters may be our best chance of detecting them. Tentative evidence has been presented for, e.g., G1, Omega Cen, and M54. These are all suspected to be the remnant nuclei of disrupted dwarf galaxies, with M54 residing at the center of the Sagittarius dwarf galaxy. IMBHs in these clusters could indicate an important connection between globular cluster black holes and the super-massive black holes known to exist in galactic nuclei. However, the line-of-sight velocity studies from which the IMBH evidence was obtained are not clear-cut. We have demonstrated that HST proper motion studies can provide much better constraints. We recently published 170,000 proper motions for Omega Cen, and our modeling of the results significantly weakened the case for an IMBH. Here we propose a similar study for M54. Ground-based spectroscopy by one of us found a peak in velocity dispersion which could be fit by either a 10^4 solar mass IMBH or an anisotropic velocity distribution; it also found a surprising offset between the kinematic and star

count centers. The proposed proper motions will validate and refine our knowledge of the dispersion peak; they will directly measure the anisotropy through the ratio of radial and tangential proper motions; and they will allow an improved determination of the kinematic center from the proper motion dispersion field. We will derive a high quality proper motion catalog of thousands of stars to put strong new constraints on the M54 cluster dynamics, structure, and possible presence of an IMBH.

OBSERVING DESCRIPTION

We will observe M54 with the WFC3/UVIS, with the F438W filter, using the subarray mode, for 2 orbits. Our observation strategy will be focused on the core of the cluster, for two reasons. First, the core is where an IMBH would reside and leave its mark. Second, the velocity dispersion in M54 drops with radius. Outside the core the proper motion velocity dispersion would be hard to measure, because it becomes comparable to our expected random errors. The choice of a blue filter is motivated by the fact that it reduces the prominence of the brightest red giant stars in the images. The choice of WFC3/UVIS over ACS/WFC is motivated by three considerations: WFC3/UVIS has a smaller pixel size, better blue sensitivity, and higher cosmetic quality (very little charge transfer efficiency degradation). The choice of subarray mode reduces overheads associated with buffer dumps, therefore allowing for more exposure time and exposures per orbit. We are planning 10 2048x2048 exposures, per orbit. The resulting field of view (FOV; 80x 80 arcsec) is more than sufficient to cover the M54 core (core radius equals 7 arcsec, half-mass radius equals 30 arcsec). The FOV will overlap 100% with the epoch 1 ACS/WFC data from GO-10775, independent of the telescope orientation. The 20 total exposures are split over 10 positions. At each position we will obtain one short (30s) and one long (200-300s) exposure. The 10 positions were chosen by Jay Anderson based on the

output of custom scripts.

REAL TIME JUSTIFICATION

N/A

CALIBRATION JUSTIFICATION

N/A

ADDITIONAL COMMENTS

N/A

Visit

Proposal 12274, Visit 01, pi Tue Aug 23 05:16:00 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Fixed Targets

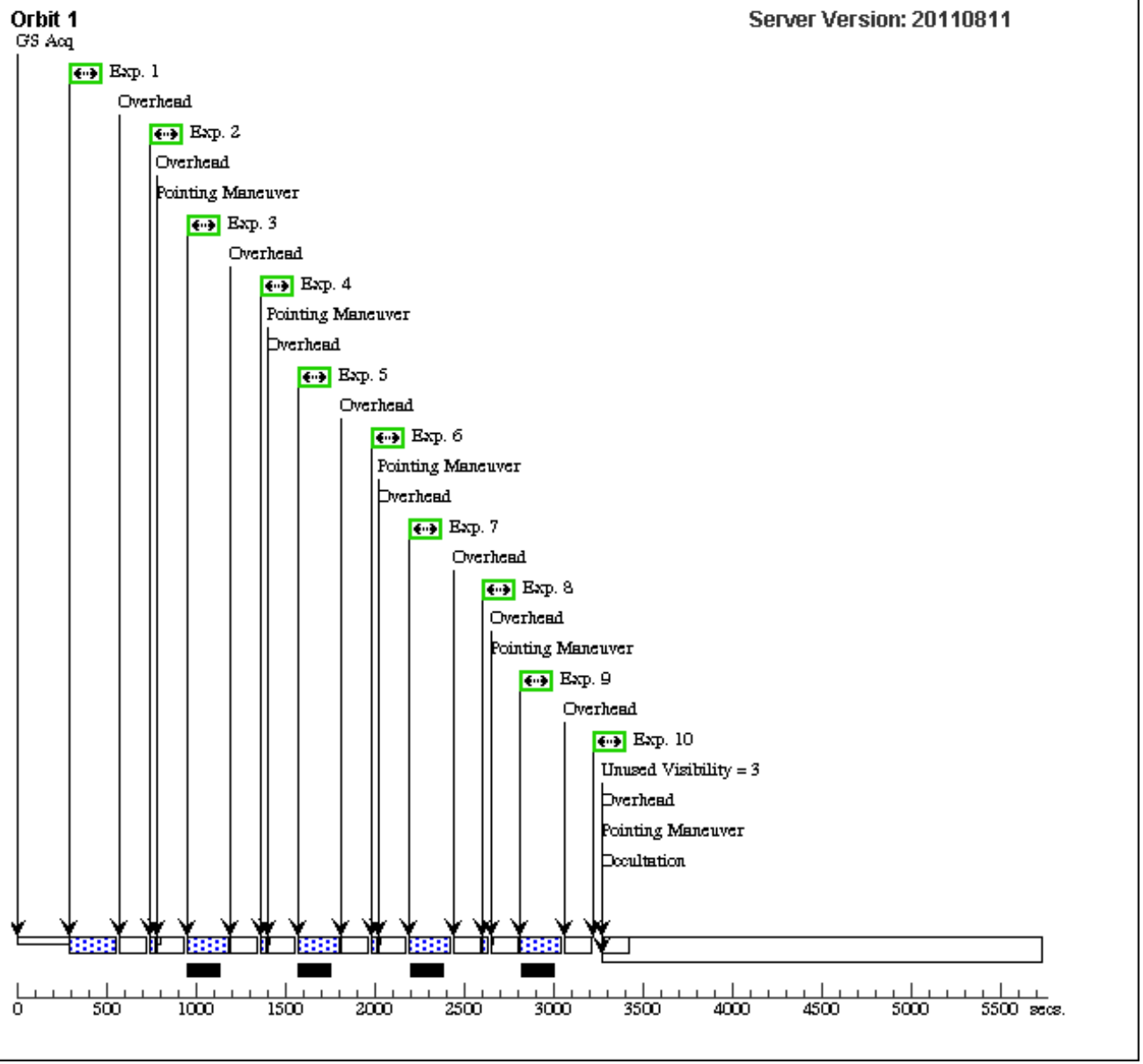
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M54	RA: 18 55 3.3300 (283.7638750d) Dec: -30 28 47.50 (-30.47986d) Equinox: J2000		V=8.37	Reference Frame: ICRS

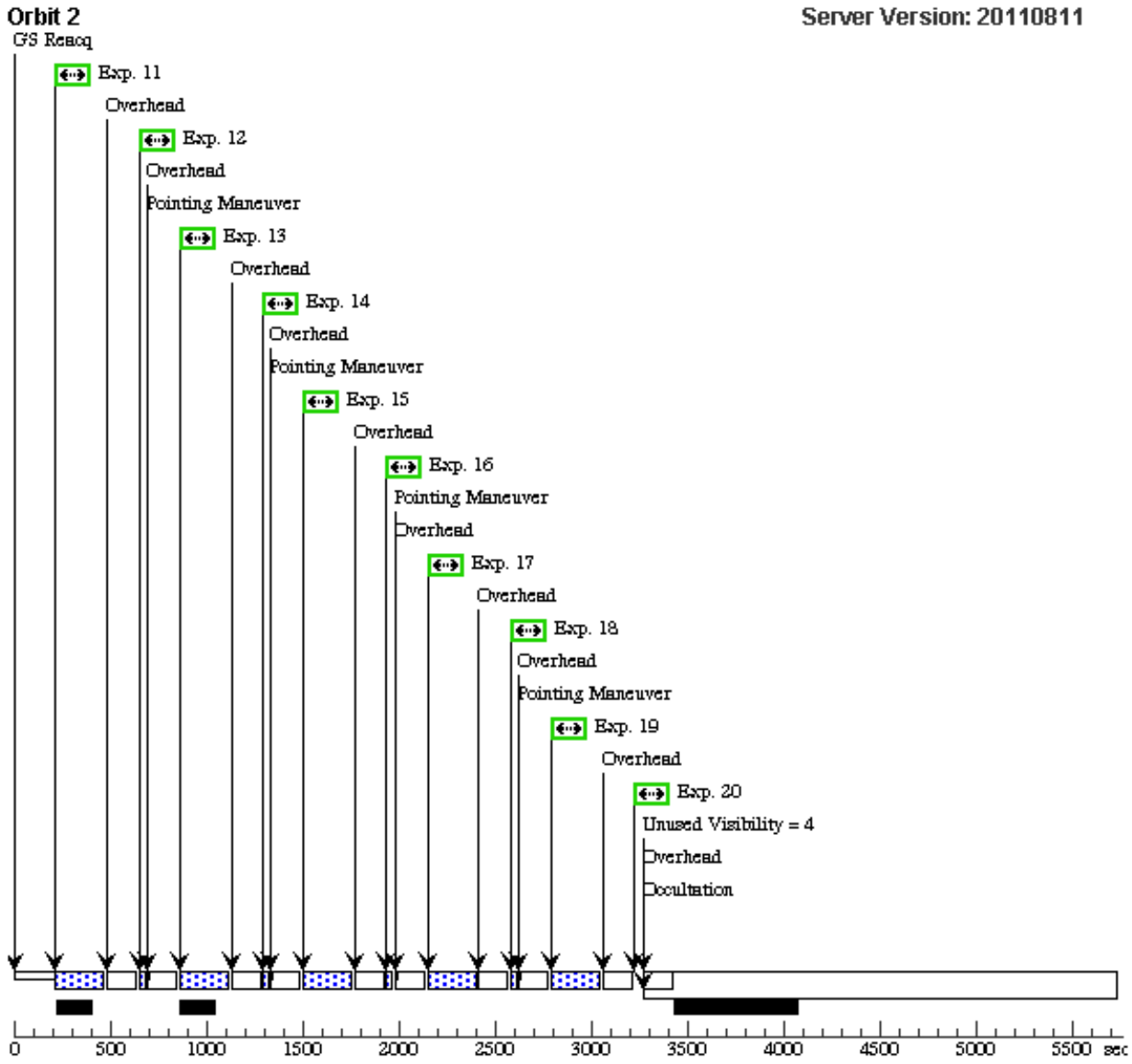
Comments: Distance is 26.8 kpc.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 10.4000 0,9.00000		200 Secs *[==>234.0 Secs]*	 ***[1]***
2		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 1		30 Secs *[==>]*	 ***[1]***
3		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 18.0604 0,2.57210		200 Secs *[==>234.0 Secs]*	 ***[1]***
4		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 3		30 Secs *[==>]*	 ***[1]***
5		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 12.1365 0,-0.84810		200 Secs *[==>234.0 Secs]*	 ***[1]***
6		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 5		30 Secs *[==>]*	 ***[1]***
7		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 5.40000, 0.33970		200 Secs *[==>234.0 Secs]*	 ***[1]***
8		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 7		30 Secs *[==>]*	 ***[1]***
9		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 1.00310, 5.57980		200 Secs *[==>234.0 Secs]*	 ***[1]***
10		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 9		30 Secs *[==>]*	 ***[1]***
11		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 1.00310, 12.42020		200 Secs *[==>256.0 Secs]*	 ***[2]***
12		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 11		30 Secs *[==>]*	 ***[2]***
13		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 5.40000, 17.66030		200 Secs *[==>256.0 Secs]*	 ***[2]***
14		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 13		30 Secs *[==>]*	 ***[2]***
15		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 12.1365 0,18.84810		200 Secs *[==>256.0 Secs]*	 ***[2]***
16		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 15		30 Secs *[==>]*	 ***[2]***
17		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 18.0604 0,15.42790		200 Secs *[==>256.0 Secs]*	 ***[2]***
18		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 17		30 Secs *[==>]*	 ***[2]***
19		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	POS TARG 20.4000 0,9.00000		200 Secs *[==>256.0 Secs]*	 ***[2]***
20		(1) M54	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F438W	CR-SPLIT=NO	SAME POS AS 19		30 Secs *[==>]*	 ***[2]***

Orbit Structure




Orbit 2
Server Version: 20110811
GS Reacq
Exp. 11
Overhead
Exp. 12
Overhead
Pointing Maneuver
Exp. 13
Overhead
Exp. 14
Overhead
Pointing Maneuver
Exp. 15
Overhead
Exp. 16
Pointing Maneuver
Overhead
Exp. 17
Overhead
Exp. 18
Overhead
Pointing Maneuver
Exp. 19
Overhead
Exp. 20
Unused Visibility = 4
Overhead
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec