13489 - Accretion Physics in Nearby FR1 Galaxies

Cycle: 21, 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) M87-NUCLEUS	COS/FUV	2	30-Sep-2013 21:50:25.0	yes
02	(2) NGC4696-NUCLEUS	COS/FUV COS/NUV	2	30-Sep-2013 21:50:36.0	yes
03	(3) HYDRA-A-NUCLEUS	COS/FUV COS/NUV	2	30-Sep-2013 21:50:47.0	yes

6 Total Orbits Used

ABSTRACT

We propose to obtain COS G130M spectra of three of the nearest FR1 radio galaxies including M87 in order to measure Lyman alpha emission line and ionizing continuum luminosities to test accretion models. The accretion process in FR1s is poorly understood. The absence of a luminous accretion disk in these "radio mode" AGN has led to various "radiatively inefficient accretion flow" (RIAF) models, but whose basic parameters

remain poorly quantified. While our serendipitous discovery of weak 10^40 ergs/s Lya emission in a few BLLac Objects strongly suggests that RIAFs must contain some cool material close to the black hole, our result was partly compromised by beaming; i.e., while the Lya emission line is unbeamed, the BLLac continuum is beamed. To overcome this shortcoming we propose to obtain COS FUV spectroscopy of representative FR1s to determine their Lya emission line luminosity, FWHM and line shape as well as their unbeamed ionizing continuum luminosity. These measurements will allow us to estimate the location, kinematics and amount of cool mass in the FR1 broad-line region. These observables will be used to test variants on the general RIAF scheme including models with "external accretion disks" and out-flowing winds and models with magnetically regulated accretion flows. By using Lya emission we can probe regions very close to the nucleus, a factor of at least ten closer than the regions probed by diffuse X-ray emission. This will allow us to assess whether the very efficient accretion suggested by the X-ray analysis is plausible or whether a more sophisticated accretion model must be developed to understand these AGN and their powerful jets.

OBSERVING DESCRIPTION

Each of our three FR 1 targets will be observed for two orbits using the COS G130M grating. While M 87 would require one orbit only to reach comparable absolute detection limits, this observation will provide the best data in our sample with which to characterize the Lyalpha emission line luminosity and width, to extrapolate to the ionizing continuum (with the help of an archival G160M spectrum) and to search for highly-ionized absorption lines (unlikely given their extreme orientation bias). For all but Hydra A, these exposure times are sufficient to detect Lya emission with a line luminosity of 1040 ergs s-1 and a FWHM = 1000 km s-1 (narrower emission will be easier to detect). Our exposure time for HydraA is based on making a high-S/N detection of both Lya and the UV continuum based on a previous IUE SWP spectrum. M 87 and Hydra A already have Lya and weak continuum detections from previous HST/FOS (Sankrit, Sembach & Canizares 1999; Figure 3) and IUE FUV spectra respectively.

NGC 4696 has only a snapshot FUSE spectrum in the FUV but the large aperture of FUSE allowed the detection of only starlight through the large (30x30") aperture. Centering the COS aperture on the nucleus of these nearby galaxies will provide best COS resolution on the nucleus and a deweighting of the intensity and spectral resolution of starlight or shock emission from the inner bulges of these galaxies because it will be mostly off-axis or outside the aperture entirely. In two of the nearest cases (M87 and NGC 4696) emission line filaments have been detected in the vicinity of the nucleus (e.g., Farage et al. 2010) but will be both depressed in intensity and offset in location even if within the COS prime observing aperture (mostly these filaments are well outside the COS 2.5" aperture). However, we will not be able to exclude the possibility that some of the Lya nuclear luminosity we detect is due to other excitation mechanisms (e.g., shocks; Dopita et al. 1997) in these nuclei. This makes the detected line luminosity a firm upper limit on the Lya produced by the nuclear non-thermal emission, but given the luminosity of the shock emission seen elsewhere in these galaxies the nuclear photo-ionized emission will be dominant.

The non-thermal continuum of these sources is likely to be quite weak. M87 has an observed FUV flux (FOS; Sankrit et al. 1999) of ~1 x 10-15 ergs s-1 cm-2A-1, which will be barely detected at native COS resolution. However, for all three sources we will smooth our spectra in bins up to 20A to detect the continuum and measure its power-law slope, a process which does not at all degrade the S/N gain because the COS FUV detectors are nearly noiseless. We expect to be able to detect the continuum down to well below
6x10-16 ergs s-1 cm-2 A-1 in these spectra after binning. These three targets were selected to span a range from little or no continuum detected (NGC 4696) to weak continuum (M 87) to moderately strong continuum (Hydra A). Regardless, we expect to detect weak Lya emission in all cases.

M87's HST Knot #1 lies 0.85" from the nucleus of M87 and will be within the COS aperture. We request a specific range of spacecraft orientations to offset the spectrum of Knot #1 0.8" in the cross-dispersion direction. France et al. (2012) have demonstrated spatially resolved spectra of sources at this separation. We will certainly be able to distinguish any Lya emission from HST Knot #1 from the nuclear emission with minimal blending.

The flux of this second source will most probably be fainter than the nucleus as it has been in all HST and Chandra observations since 2006. Even if 10 times brighter than in recent observations, its presence will not over-range the COS detectors using the G130M grating. Even a 10x brightening is a larger flare than the peak in March-May 2005 (Harris et al. 2006). Furthermore, the off-center position of HST Knot #1 will reduce the its flux by 33% due to vingetting in the COS aperture.

Visit

Proposal 13489, M87 nucleus (01), implementation Tue Oct 01 01:50:56 GMT 2013

Diagnostic Status: Warning

Scientific Instruments: COS/FUV

Special Requirements: ORIENT 46D TO 84 D; ORIENT 226D TO 264 D

Diagnostics

(M87 nucleus (01)) Warning (Form): For the best data quality, it is strongly recommended that all four FP-POS positions be used when observing at a given COS CENWAVE setting.

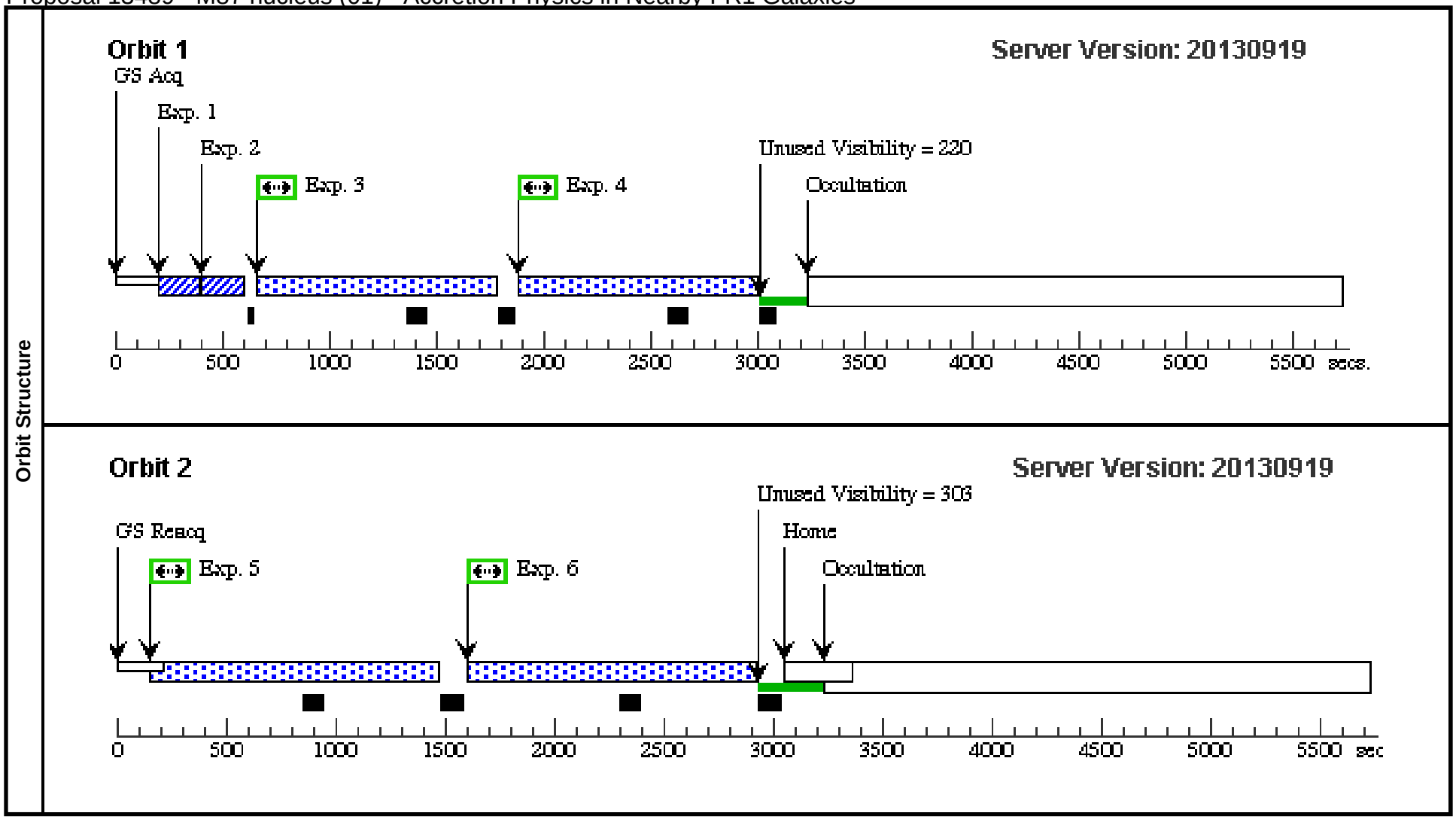
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M87-NUCLEUS	RA: 12 30 49.4234 (187.7059308d) Dec: +12 23 27.04 (12.39084d) Equinox: J2000		V=8.63 f(FUVcontinuum)<1e-15 erg cm -2 s-1 A-1	Reference Frame: ICRS

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

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.535 570)	(1) M87-NUCLEUS	COS/FUV, ACQ/PEAKXD, PSA	G130M 1318 A				30 Secs (30 Secs) *[==>]*	*[1]*
Comments: Penton's suggested strategy 9/27/13									
2	(COS.sa.535 570)	(1) M87-NUCLEUS	COS/FUV, ACQ/PEAKD, PSA	G130M 1318 A	NUM-POS=5; STEP-SIZE=1			10 Secs (10 Secs) *[==>]*	*[1]*
3	(COS.sp.510 442)	(1) M87-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1318 A	BUFFER-TIME=600; FP-POS=1			1000 Secs (1000 Secs) *[==>]*	*[1]*
4	(COS.sp.510 442)	(1) M87-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1309 A	BUFFER-TIME=600; FP-POS=2			1000 Secs (1000 Secs) *[==>]*	*[1]*
5	(COS.sp.510 442)	(1) M87-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1300 A	BUFFER-TIME=600; FP-POS=3			1200 Secs (1200 Secs) *[==>]*	*[2]*
6	(COS.sp.510 442)	(1) M87-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=600; FP-POS=4			1200 Secs (1200 Secs) *[==>]*	*[2]*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Exp. 3
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2000
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3000
3500
4000
4500
5000
5500
secs.
Orbit 2
Server Version: 20130919
Unused Visibility = 306
GS Reacq
Home
Exp. 5
Exp. 6
Occultation
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1000
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2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 13489, ngc4696 nucleus (02), scheduling Tue Oct 01 01:50:58 GMT 2013

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(ngc4696 nucleus (02)) Warning (Form): For the best data quality, it is strongly recommended that all four FP-POS positions be used when observing at a given COS CENWAVE setting.

Fixed Targets

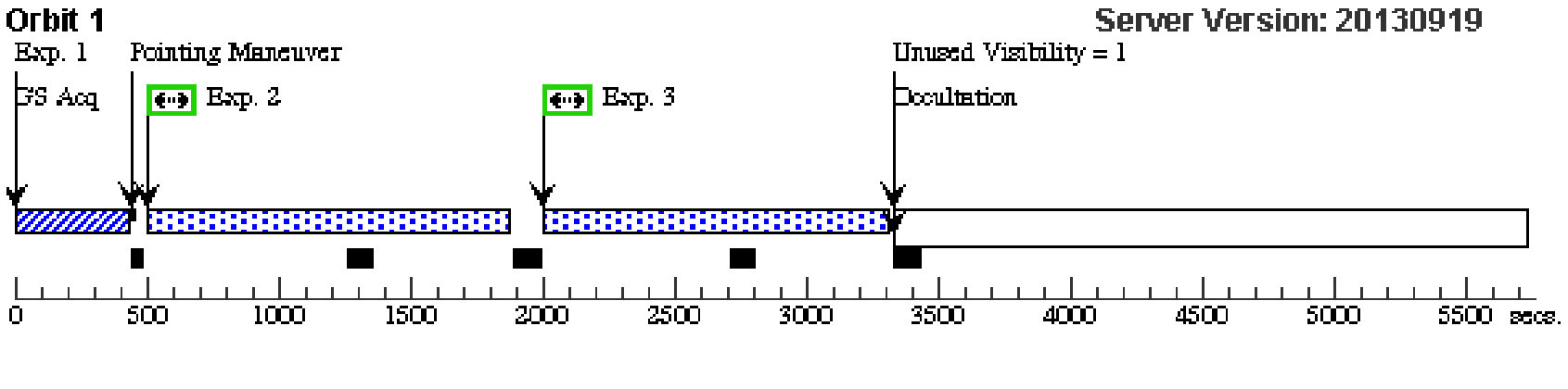
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	NGC4696-NUCLEUS	RA: 12 48 49.2569 (192.2052371d) Dec: -41 18 39.34 (-41.31093d) Equinox: J2000		V=12.8+/-1	Reference Frame: ICRS

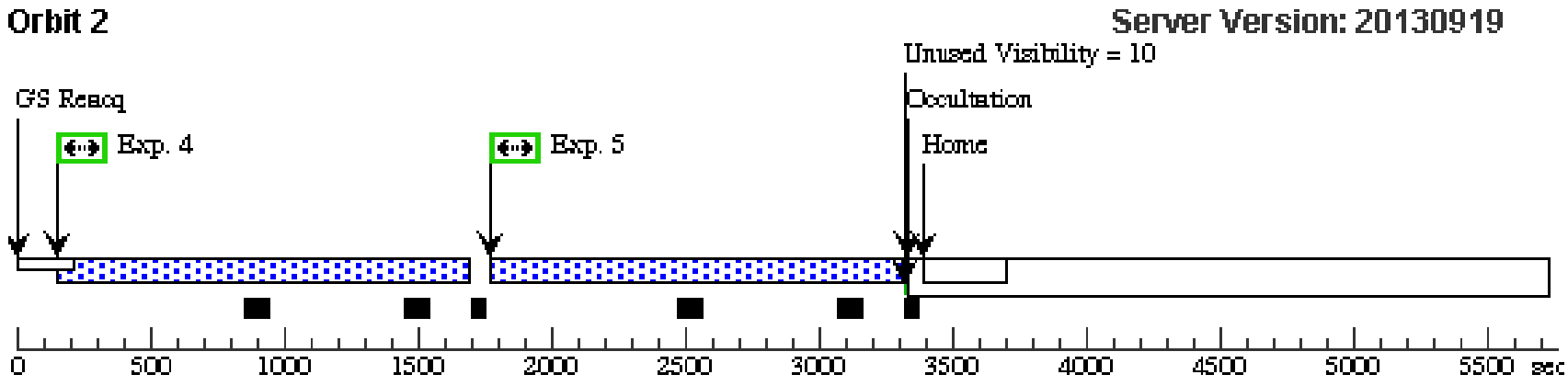
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Coordinates checked in GSC2.3 (hstID=2MIOY63L)

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.510441)	(2) NGC4696-NUCLEUS	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				15 Secs (15 Secs) *[==>]*	***[1]***
Comments: HST program 12260 acquired M87 nucleus with a 12 second exposure. We duplicate that exposure here but use a more conservative continuum flux estimate.									
2	(COS.sp.510442)	(2) NGC4696-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=600; FP-POS=1			900 Secs (1191 Secs) *[==>1191.0 Secs]*	***[1]***
3	(COS.sp.510442)	(2) NGC4696-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1300 A	BUFFER-TIME=600; FP-POS=2			900 Secs (1191 Secs) *[==>1191.0 Secs]*	***[1]***
4	(COS.sp.510442)	(2) NGC4696-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1318 A	BUFFER-TIME=600; FP-POS=3			900 Secs (1417 Secs) *[==>1417.0 Secs]*	***[2]***
5	(COS.sp.510442)	(2) NGC4696-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=600; FP-POS=3			900 Secs (1417 Secs) *[==>1417.0 Secs]*	***[2]***

Orbit Structure





Visit

Proposal 13489, hydra a nucleus (03), scheduling Tue Oct 01 01:50:59 GMT 2013

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(hydra a nucleus (03)) Warning (Form): For the best data quality, it is strongly recommended that all four FP-POS positions be used when observing at a given COS CENWAVE setting.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	HYDRA-A-NUCLEUS	RA: 09 18 5.6740 (139.5236417d) Dec: -12 05 43.92 (-12.09553d) Equinox: J2000		V=14.8	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Coordinates courtesy of Greg Taylor from VLBI measurements.

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.510441)	(3) HYDRA-A-NUCLEUS	COS/NUV, ACQ/SEARCH, PSA	MIRRORA	SCAN-SIZE=2; CENTER=BRIGHTEST			15 Secs (15 Secs) *[==>]*	***[1]***
Comments: HST program 12260 acquired M87 nucleus with a 12 second exposure. We duplicate that exposure here but use a more conservative continuum flux estimate.									
2	(COS.ta.510441)	(3) HYDRA-A-NUCLEUS	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				60 Secs (60 Secs) *[==>]*	***[1]***
3	(COS.sp.510442)	(3) HYDRA-A-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=600; FP-POS=1			900 Secs (990 Secs) *[==>990.0 Secs]*	***[1]***
4	(COS.sp.510442)	(3) HYDRA-A-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1309 A	BUFFER-TIME=600; FP-POS=2			900 Secs (990 Secs) *[==>990.0 Secs]*	***[1]***
5	(COS.sp.510442)	(3) HYDRA-A-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1318 A	BUFFER-TIME=600; FP-POS=3			900 Secs (1380 Secs) *[==>1380.0 Secs]*	***[2]***
6	(COS.sp.510442)	(3) HYDRA-A-NUCLEUS	COS/FUV, TIME-TAG, PSA	G130M 1327 A	BUFFER-TIME=600; FP-POS=3			900 Secs (1380 Secs) *[==>1380.0 Secs]*	***[2]***

Orbit Structure