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COS Lifetime Position 6 Enabling Summary

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ABSTRACT

We summarize the activities performed to enable lifetime position 6 (LP6) for the Cosmic Origins Spectrograph (COS) instrument on the Hubble Space Telescope (HST). LP6 is located +6.5" above LP1. All G160M cenwaves were enabled at LP6, which became the default LP for G160M exposures on 2022 October 3, at the beginning of Cycle 30. This ISR presents an overview of the LP6 enabling programs, which includes target placement, focus sweep, and target acquisition enabling and verification.

Contents

1. Introduction

The COS far-ultraviolet (FUV) detector experiences the most severe gain sag in regions where science spectra are projected. To maintain the quality of COS science data, periodic lifetime position (LP) moves are required, moving the location of the projected science spectra, a process that has been taking place since 2012. In addition to LP moves, certain observing modes are placed at different LPs to be operated in parallel with one another to prolong the lifetime of the detector. To extend the lifetime of LP4, observations of faint targets taken with G160M were determined to be best moved to LP6. The COS team enabled operations for LP6 in Cycle 29, for scientific operations starting in Cycle 30. The observations taken as part of the enabling programs were collected in preparation for the calibration of LP6 (Sankrit et al. 2023). At the beginning of Cycle 30, LP6 became the default for G160M observations, with exposures of duration more than half an orbit per target per FP-POS taking place at this LP. Short exposures (less than half an orbit per target per FP-POS) continue to be taken at LP4 where overheads are lower. LP6 is located $+6.5''$ above LP1, and the choice of placement is described in James et al. (2023). G130M observations are taken at LP5 with the exception of the blue modes G130M/1055 and 1096 which are located at LP2, and G130M/1222 exposures which are located at LP4. G140L observations continue to be observed at LP3. This report presents an overview of the LP6 enabling programs and their deliverables, with the details presented in separate ISRs. Plesha et al. (2022) summarizes the activities when commissioning a new LP in general. James et al. (2023) summarizes the exploratory phase for LP6.

2. Overview of the LP6 Enabling Programs

Three programs totaling 14 orbits were executed from December 2021 to October 2022 to enable the use of LP6, and are largely modeled on those from previous LP moves. Compared to previous enabling programs, some modifications to the targets were made so that they were bright enough while using the G160M grating, such that for WD1337+705 and for WDG-1 the target S/N was ~ 5.5 per resel, and for Feige 48 the target S/N was $\sim$ 30 in the reddest part of the spectrum. Table 1 lists the program information.

All data were manually set to bypass calibration in the Barbara A. Mikulski Archive for Space Telescopes (MAST) archive, since reference files for LP6 were not available in the Calibration Reference Data System (CRDS) at the time. Due to the light leak through the Flat-field Calibration Aperture (FCA) at >5.8" above LP1, TAGFLASH wavecals were disabled (FLASH=NO, WAVECAL=NO) in APT. None of the data in the enabling programs required wavelength-calibrated data, so SPLIT-wavecals were not performed, to minimize overheads, and avoid complications with SPLIT-wavecal operations (Soderblom et al. 2022, James et al. 2023), which were in development at the time of program execution.

Table 1. Overview of the LP6 enabling programs.

Prog. ID	Title	Orbits	Target
16849	Verification of Target Placement for COS at LP6	2	WD1337+705
16850	FUV Focus Sweep for COS: LP6 Enabling	8	Feige 48
16851, 17246	COS LP6 FUV Target Acquisition Enabling and Verification	4	WDG-1

PID 16849 (Verification of Target Placement for COS at LP6; PI A. Hirschauer) observed the flux standard white dwarf WD1337+705 with the aim of determining the optimal centering of the target in the COS aperture, and any minor updates to the Science Instrument Aperture File (SIAF), which supplies the locations of all COS apertures at every LP. The program is described in detail in Hirschauer et al. (2023). It was determined that small shifts of -0.07208 arcsec and -0.00143 arcsec in the V2 and V3 coordinates, respectively, were needed to update the SIAF, which was delivered in February 2022 in time for the LP6 calibration programs to start executing.

PID 16850 (FUV Focus Sweep for COS: LP6 Enabling; PI T. Fischer) observed the star Feige 48 with the aim of measuring the optimal focus position for G130M/1222 and G160M/1600 by measuring the cross-correlation function of spectral features at different focus positions. This target was observed instead of the preferred focus target AzV 75, which was not visible at the time of program execution. The program needed to execute in a certain timeframe to ensure a timely start of LP6 operations at the beginning of Cycle 30. The program is described in detail in Fischer et al. (2023). The focus was measured successfully and updated in the patchable constants table in the flight software, in time for the LP6 calibration programs to start executing.

PID 16851, 17246 (COS LP6 FUV Target Acquisition Enabling and Verification; PI S. Dieterich) observed the white dwarf WDG-1 to determine the accuracy of centering the target in the COS aperture using three spectroscopic acquisition modes. The program is described in detail in Dieterich et al. (in prep). Program 16851 determined that all spectroscopic acquisition modes worked as expected at LP6 for G160M during three visits spread over a period of several months, concluding with a final visit a few days after the start of Cycle 30 (PID 17246). None of the LP6 calibration programs used spectroscopic acquisitions, and COS science exposures could not use spectroscopic acquisitions at LP6 until the tests were successful. The last visit of PID 16851 was copied into PID 17246 to facilitate the program to execute with the default Cycle 30 APT parameters instead of those for Cycle 29.

After the successful updates to the SIAF and flight software with the values determined from these enabling programs, calibrations for LP6 were able to begin in February 2022. After the successful tests of the spectroscopic target acquisitions, the enabling phase was completed, and LP6 science operations began on 2023 October 3.

Table 2. Overview of PID 16849: Verification of Target Placement for COS at LP6.

Topic	Details
Purpose	The aperture block was set at -11 steps for LP6, corresponding to approximately +6.5" from LP1 for gain and optical performance reasons. The data from this program were used to make minor adjustments to the Science Instrument Aperture File (SIAF) in order to center the target in the fixed LP6 aperture.
Description	One visit to take a series of G160M/1600 FP-POS=3 observations scanning the target over the aperture in the dispersion and cross-dispersion directions using POSTARG offsets, following the same structure as the LP5 program (Frazer et al. in prep).
Observations	Two external orbits were required using target WD1337+705. The Optional Parameter LIFETIME-POS=LP6 was used in order to use the pointing, aperture position, and detector high voltage values for LP6 determined from LP6 exploratory data.
Deliverables	Minor updates to the HST pointing (V2, V3) values in the SIAF file to accurately center the target in the fixed aperture.
Accuracy Goals	The target pointing located to within 0.05 arcsec.
Scheduling Requirements	The program needed to be executed early in the enabling phase such that updates could be made to the SIAF before executing other LP6 enabling and calibration programs. The plan window was October 27 to December 8, with a backup window of December 17 to January 26. The backup window had to be utilized due to a safing event with *HST* which affected the primary plan window.
Documentation	COS ISR 2023-06 (Hirschauer et al. 2023)

3. Program summaries

Details of the programs can be found in Tables 2, 3 and 4, and the results of the enabling programs can be found in their respective ISRs.

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Change History for COS ISR 2024-03

Version 1: 19 February 2024- Original Document

Table 3. Overview of PID 16850: FUV Focus Sweep for COS: LP6 Enabling.

Topic	Details
Purpose	An enabling program to verify the focus of the FUV channel for G160M/all and G130M/1222 modes at LP6.
Description	Visit 03 – G130M/1222 FUVA and FUVB scan with target Feige 48. Visit 04 – G160M/1600 FUVA and FUVB scan with target Feige 48.
Observations	Three external orbits for the G130M/1222 scan, five external orbits for the G160M/1600 scan for a total of 8 external orbits.
Deliverables	The best focus for each mode at the new LP6 position on the detector.
Accuracy Goals	Determine the best focus positions to within ± 100 focus steps.
Scheduling Requirements	The program needed to be executed early in the enabling phase such that updates could be made to the focus before executing other LP6 enabling and calibration programs. Due to a safing event with *HST* this meant the program utilized a backup plan window and target.
Documentation	COS ISR 2023-19 (Fischer et al. 2023)

References

Dieterich, S., et al. in prep, COS Instrument Science Report 2024-XX
Fischer, T., et al. 2023, COS Instrument Science Report 2023-19
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Plesha, R., et al. 2022, COS Technical Instrument Report 2022-03
Sankrit, R., et al. 2023, COS Instrument Science Report 2023-25 Soderblom, D., et al. 2022, COS Data Handbook, Version 5.1, (Baltimore: STScI)

Table 4. Overview of PID 16851 and 17246: COS LP6 FUV Target Acquisition Enabling and Verification.

Topic	Details
Purpose	(1) Verify FUV spectroscopic target acquisition (TA) parameters, and verify TA modes at LP6. (2) To provide diagnostic data regarding positioning of acquisition within subarray in case problems are encountered.
Description	Program verified the operations of the three acquisition modes used in FUV: ACQ/SEARCH, ACQ/PEAKD, and ACQ/PEAKXD. In each case a target was acquired using an NUV imaging acquisition, the telescope was offset, and the target was re-acquired in the FUV to test the respective modes. Tests were conducted with cenwave G160M/1577, which is the widest cross-dispersion profile used for acquisition at LP6. Because dispersed light acquisition spectra do not get downlinked, POSTARG displacements were used to replicate these observations and downlink them to verify the placement of spectra in the acquisition subarray.
Observations	Four visits of one external orbit each. Visit 1: ACQ/SEARCH, Visit 2: ACQ/PEAKD, Visit 3 ACQ/PEAKXD, Visit 4: Verification test, testing defaults soon after the official installation of the flight software patches were made, which was soon after Cycle 30 operations began.
Deliverables	Verification of TA subarray placements, verification of TA flight software functionality, derivation of offsets needed if were array placement problems, mapping/detection of any significant detector features in the TA area.
Accuracy goals	0.11" to 0.18" accuracy in the dispersion direction, 0.3" accuracy in the cross-dispersion direction.
Scheduling Requirements	Executed after: (1) All subarrays defined in the flight software, (2) aperture placement verified by program 16849, (3) focus verified by program 16850. To allow for analysis and changes before SMS builds, these values were identified 3 weeks before Visit 01 and it was required that there be at least three weeks between visits. Visit 04 ran close to the first day of Cycle 30 operations. No FUV science acquisitions using G160M were performed in the first 3 weeks of Cycle 30 to allow for analysis of the last visit before SMS builds. The program used fictitious offset targets to nod the telescope away from a centered target and then test the re-acquisition. Because these displacements were along the along-dispersion and cross-dispersion detector direction, target offset coordinates were entered in RA and DEC, and the ORIENT angle for each visit was restricted to ± 0.5 degrees, which also meant a date range restriction. This resulted in visit windows spanning a few days.
Documentation	COS ISR 2024-XX (Dieterich et al. in prep)