LONG TERM FOS CALIBRATION PLAN: CYCLE 1

CAL/FOS-062

A.L. Kinney and G.F. Hartig
August, 1989

INTRODUCTION

The Faint Object Spectrograph is one of the two most requested ST instruments. Out of a total of 1581.5 hours of requests in high priority accepted GO programs, there were requests for 478 hours of FOS time, utilizing most of the valid instrument modes and configurations. (FOS is running a close second to WF/PC, which was requested for 590 hours.) It is clear that the long term and steady state calibration of FOS will involve a major commitment of telescope time. The plan presented here includes all the calibrations that we think are necessary for maintaining the level of calibration achieved after Science Verification (SV) plus fundamental calibrations which were not done in SV due to time constraints. They are prioritized according to the importance of the calibration. This plan requires 74.2 hours of spacecraft time; 42.1 for maintaining the accuracies achieved in SV, and 32.1 hours for extending the calibrations performed in SV.

The long term FOS calibration plan is based on the SV plan developed by the FOS IDT and coordinated by Ron Downes. This cycle 1 plan includes some calibrations that will *probably* not be carried out in SV because they are designated to the 'delta' plan. This plan also includes as many of the calibrations that are obviously required by GO programs as possible. However, because the GO proposals have not yet been through phase 2, the required apertures and configurations are uncertain. *We expect that the cycle 1 FOS calibration program will have to be modified after phase 2 and that further modification will likely be required based on the experience obtained during SV.*

The cycle 1 calibration plan is designed to maintain and to extend the calibrations of SV. A breakdown of the spacecraft time requested to maintain, as opposed to extend, SV accuracies is given in Table 1, along with the program priority, the targets, and the SDAS tools that will be used to analyze the results. Abstracts of all programs are included which summarize the state of the particular calibration at the end of SV, the exact configuration to be calibrated, the way in which the data will be incorporated into pipeline calibration, and the total spacecraft time. The expected calibration accuracies for SV are given in the STScI Newsletter Vol. 4 No. 4, page 9. The accuracies quoted in the Newsletter will also

apply to the additional configurations calibrated in cycle 1.

Priority 1 calibrations are those that are required before *any* spectra can be taken with FOS. Priority 1 programs include determination of the locations of the FOS apertures, the locations of the spectra on the photocathode (Y-Base) and a check of PERIOD mode. More complete versions of both tests are scheduled in SV. The first two tests run every few months to verify repeatability and to track any long-term drift in the instrument. The PERIOD mode check will be done only if it is not carried out in SV, which is quite likely because it is a 'delta' plan test.

Priority 2 calibrations are those that provide fundamental calibration of the instrument. They include absolute photometric calibration, flat fielding, and wavelength calibration About half of the time requested for priority 2 programs is for calibrating configurations that were not included in SV. For example, the absolute photometric calibration obtained in SV does not apply to the paired apertures, so they are calibrated in this plan.

Priority 3 calibrations include pulse height analysis, which is an engineering test, polarimetric calibration, and dark count and sky measurement. The only priority 4 calibration is a measurement of the efficiency of the occulting aperture.

ABSTRACTS

Aperture Locations Priority 1

Aperture locations and sizes are measured in 4 phases (described in detail in *Aperture Locations and Sizes for the ST SIs* by Lupie, Bohlin, and Holm) in OV and in SV. A trimmed down version of the SV aperture location measurement (performed in only the 0.1-PAIR-B aperture and using onboard acquisition) will be done every 4 months on both the red and the blue sides in cycle 1 to verify repeatability and to measure any long-term drift in the aperture locations. Any changes in the aperture positions will be used to update the Project Data Base (PDB) aperture files (SIAF.DAT). This program has the highest priority because all FOS observations depend on our knowledge of aperture location. Total spacecraft time is 6.5 hours plus 2.4 hours of parallel observations.

Y-Base Maps Priority 1

Locations of spectra are measured in OV twice and in SV 7 times (once with a measurement at all apertures at two grating settings plus all grating settings using 2 apertures, and

ment at all apertures at two grating settings plus all grating settings using 2 apertures, and 6 times with one aperture at all grating settings). In cycle 1 we will measure the location of spectra for the 0.3" aperture at all grating settings once every 3 months to verify repeatability and measure any long-term drift. This test will also measure the filter-grating wheel repeatability. Any change in Y-Base values will result in an update of the PDB Y-Base files (SICS.DAT). This test has the highest priority because our ability to acquire spectra depends on our knowledge of Y-Base values. Total spacecraft time is 1.9 hours of *parallel* observations.

PERIOD Mode Priority 1

The testing of PERIOD mode is in the 'delta' SV plan. If the test is not carried out in SV then it is a priority 1 test for cycle 1.

In order to verify the functionality of the PERIOD mode of FOS, a stable high-frequency variable star with a well-measured period will be observed. The PERIOD mode constitutes a minority of FOS observations, but forms one of the features that is unique to the instrument. We propose to observe one of two standards - the Crab Pulsar or DQ-HER - using the synchronous time-resolved mode. Total spacecraft time is 1.4 hour for the Crab Pulsar (the higher priority target) and 2.3 hours for DQ-HER.

Absolute Photometric Calibration Priority 2a

Absolute sensitivity of the FOS will be determined in SV by observing two stars at three epochs, first in three apertures (1.0", 0.5", and 0.3") and then in one aperture (1.0"). In cycle 1, two stars will be observed at three epochs in the 1.0" aperture to establish the stability of the sensitivity, and one star will be observed at one epoch in the paired apertures, which are not calibrated in SV. Only those paired apertures selected for GO and GTO programs will be calibrated. The stars will be observed in each reasonable detector/grating combination (a total of 14). The data will be averaged to form the pipeline response functions for the FOS. The inverse sensitivity is referenced from the relation CYIVSR. If three of the four paired apertures are calibrated, total spacecraft time will be 30.6 hours.

Flat Fields Priority 2b

The diode-to-diode variations and photocathode non-uniformities of the FOS detectors will be determined by measurement of stellar sources with featureless continua through the 1.0" single aperture in SV. The flat field test will be run again in cycle 1 to verify stability and to fill in data for spectra taken in the paired apertures, which lie on different photocathode locations. Two stars will be observed in each reasonable detector/grating combination (a total of 14). The spectra will have any remaining stellar features extracted

and will be averaged to form the pipeline spectral flat fields for the FOS (which are referenced from the relation CYFLTR). Total spacecraft time is 12.5 hours (4.2 hours to maintain SV and 8.3 hours to extend SV).

Internal/External Wavelength Offsets and Line Spread Function Priority 2c

Offsets between internal and external wavelength scales will be measured in SV for 3 gratings on the blue side and for 6 gratings on the red side. In cycle 1, G270H and the prism will be measured on the blue side and G190H and G160L will be measured on the red side to fill in gaps in the coverage in SV, and 2 gratings will be repeated on each side to verify stability. (Monitoring will be done in the absolute photometric calibration.) The test will be performed with all dispersers, using two different apertures on three external sources. Any derived offsets can be applied to the polynomial fit of pixel number versus wavelength determined from the spectra of the internal Pt-Cr/Ne lamp. The wavelength parameters will be used to update the CDBS reference file CYCCS6R. Unresolved lines in planetary nebulae and in a dMe star will be used to determine the FOS + ST Line Spread Function. The internal sources make up only 5% of the exposure time and must be acquired at the same time as the external sources, so they cannot be scheduled as parallel observations. Total spacecraft time is 16.7 hours (8.35 hours to maintain SV calibration and 8.35 hours to extend SV calibration).

Pulse Height Analysis Priority 3a

The optimal discriminator settings will be determined in OV. Because both the noise and gain are known to be temperature sensitive, it is likely that some fraction of the channels will experience some change in their optimal discriminator threshold settings on orbit. The discriminator/noise test should be run twice in cycle 1 to verify the stability of those settings.

The FOS high voltage will be brought to approximately one-half the nominal operating voltage (12750 KV), with the REFDAC=250 and the trim focus current at 0. A 60s wait will allow the high voltage to stabilize. The command block YTDN will be run, with the INTFLAT as the source. Total time is 3.0 hours *parallel.*

Polarimetric Calibration Priority 3b

By the end of SV, 7 combinations of detector, disperser, and waveplate will be calibrated (G130H and G160L on the blue side with the B waveplate and the Prism on the blue side with the A wavelplate and G270H and G190H on the red side with the B waveplate and the Prism on the red side with both the A and the B waveplate). The Y-Bases are measured for these combinations, along with the throughput and the instrumental polarization, and spectral flat fields and wavelength calibrations are performed. To maintain

this level of calibration for cycle 1, the same parallel-time calibrations will be performed but the observations of external target will be greatly reduced by observing at only one angle of the waveplate and at only one spacecraft position angle. The waveplate parameters are used to update the CDBS reference files CYCCS4R and retardation is referenced by the relation CYRETR. The total spacecraft time is 3.8 hours plus 2.6 hours of parallel time.

Dark Count and Sky Measurement Priority 3c

Internal dark and external sky measurements will be made in SV when other instruments are prime. Because these parallel observations require very complicated scheduling and commanding, we do not know how much of the program will be completed in SV. The size of the cycle 1 Dark Count Measurement program depends on how much of the SV program is carried out.

The sky data will be obtained at high galactic latitude, low galactic latitude, and in the ecliptic plane. These observations will allow us to determine when sky measurements will be required for correct interpretation of science data. The dark measurements will be obtained with a variety of SIs prime and during SAA passages. All dark observations will be read from several different portions of the photocathode, to check if the dark count is position dependent. If it is not, then normal science dark measurements can be obtained by changing the Y-Base rather than closing the entrance aperture, thus allowing for more efficient observing. The background reference files are indexed in CDBS from the relation CYBACR. This program requires only parallel observations.

Occulting Aperture Priority 4

The efficiency of the occulting apertures will be tested in SV and again in cycle 1 to verify stability of aperture size and location. A bright star will be centered in the 0.3" single aperture and then placed behind the occulting bar of the $0.7 \times 2.$ aperture and the unocculted light will be measured by obtaining spectra with the prism. This is performed once on the red side and once on the blue side. Total spacecraft time is 2.7 hours.

Table 1

Summary of FOS Cycle 1 Calibration Plan

Type of Calibration	Priority	Baseline SV Program	Spacecraft Time	Targets	STSDAS Tools
Aperture Location PI: AK	1	1527	6.5 hrs (2.4 hrs parallel)	NGC-188-031 (GSC4619-2765)	aperlocy apscale
Y-Base Maps PI: GH	1	1309	(1.9 hrs parallel)	Cal Lamp	ybase
PERIOD Mode PI: AK	1	1315	1.4 hrs **	Crab Pulsar or DQ-HER	
Absolute Photometric PI: GH	2a	1320	30.6 hrs (16.5 hrs)* (14.1 hrs)**	BD+75	absfity absseny deadtimy
Flat Field PI: AK	2b	1318	12.5 hrs (4.2 hrs)* (8.3 hrs)**	0005+5106 (GSC3528-1003) G191B2B, (GSC3734-0506) PG1034+001	flatfield
Wavelength PI: GH	2c	1317	16.7 hrs (8.35 hrs)* (8.35 hrs)**	NGC185-1, NGC6822-1, M32-1, UV-CETI, AT-MIC, YZ-CMI	dispfity linefind waveoffset fitoffsety

Spacecraft time is calculated in RESOURCE command of RPSS. * Total time for the portion of the test that maintains SV accuracies. ** Total time for the portion of the test that extends SV calibrations.

Table 1

Summary of FOS Cycle 1 Calibration Plan, continued

Type of Calibration	Priority	Baseline SV Program	Spacecraft Time	Targets	STSDAS Tools
Pulse Height Anaylsis PI: GH	3a	OV	(3.0 hrs parallel)	flat field LED	phay
Polarimetric PI: AK	3b	1430	3.8 hrs (2.6 hrs parallel)	SAO-11597 WD0501+527 (GSC3734-0506)	TBD
Dark Count Measurement PI: GH	3c	1316	(25 hrs parallel)		parthity
Sky Measurement PI: GH	3d	1316	(25 hrs parallel)		
Occultation Aperture PI: AK	4	1319	2.7 hrs	BD+33D2642	
Total Spacecraft Time			74.2 hrs		
Total time for tests to maintain SV accuracies			42.1 hrs		
Total time for tests which extend SV calibrations			32.1 hrs		

Spacecraft time is calculated in RESOURCE command of RPSS. * Maintain SV. ** Extend SV.