Faint Object Spectrograph Instrument Status and Performance Changes: 1990 - 1993

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I. Introduction

The Faint Object Spectrograph (FOS) is operating well and all instrumental modes are functional. There have been several areas of operation or calibration that have required some procedural change or enhancement as compared with the methodologies envisioned prior to launch. Among these are the characterization of temporal changes to the flat field for certain detector/disperser combinations, temporal changes to the absolute photometric sensitivity , and geomagnetically-induced image motion (GIM) which has necessitated an additional calibration operation and subsequent modification to the onboard data-taking.

Additionally , calibration updates for expected instrumental changes must be made on a continuing basis. For example, as time goes by the number of dead or noisy diodes that must be corrected increases, necessitating a newly expanded dead-diode table listing after each change. Also known prior to launch, yet still awaiting full characterization, is the problem of scattered light in the spectrograph and its contribution to the detected counts, especially for ultraviolet spectral elements.

Table 1 summarizes the status of processing for each type of calibration operation. Note that processing status of some operations may be distinctly different for datasets acquired from the archive as opposed to that of observations processed for the original observers.

II. Geomagnetically-Induced Image Motion (GIM)

The GIM (also referred to as GIMP – Geomagnetically-induced Image Motion Problem) affects the FOS/RED detector at least four times more strongly than it does the FOS/BLUE. The FOS/RED image motion, which can be as much as 1.25 diodes, was characterized precisely as a function of the ambient geomagnetic field on orbit as the result of a series of calibration observations made in the spring of 1991.

A post-observation correction algorithm for use in the FOS calibration pipeline (CALFOS) procedures was implemented in PODPS by October 1, 1991. This procedure can correct only for GIM motion parallel to the diode array (X- or dispersion-direction) and is applied only to ACCUM, RAPID, PERIOD, and, if specifically requested by the proposer , POLSCAN modes of data-taking. The standard FOS/RED ACCUM mode frame time was shortened from 4 minutes to 2

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minutes and the correction is applied according to the geomagnetic field appropriate to each individual frame of an ACCUM exposure. Nonetheless, the accuracy of this method is not sufficient to allow meaningful polarimetry to be performed with FOS/RED. FOS/BLUE ACCUM frame time remains at 4 minutes and polarimetry is feasible due to the much smaller GIM motion for this detector. The entire *HST* archive of data taken before implementation of the pipeline GIM correction has been completely re-processed with the post-observation correction.

An onboard algorithm was implemented on April 5, 1993. This correction is applied both parallel and perpendicular to the line of diode centers. The correction is computed and applied every 30 seconds during data-taking. As a result, the actual data stored onboard the spacecraft are modified prior to their transmission to the ground – there is no way to remove the onboard GIM correction from the data. The correction is applied not only to ACCUM, RAPID, PERIOD, and POLSCAN observations, but to ACQ mode, as well. The accuracy of the onboard algorithm is 10 percent of the width of a diode or approximately 0.04 arcsec.

The onboard GIM correction is enabled by default for any proposal processed by TRANSFORMATION after September, 1992. Header keywords YFGIMPEN (GIM correction enabled: TRUE or FALSE) and YFGIMPER (GIM processing error: YES or NO) provide the status of onboard GIM processing. Onboard GIM correction can be turned off only by proposal specification. Pipeline GIM processing would be performed in such a case. NOTE: CALFOS will sternly warn of any attempt to perform pipeline GIM correction on data that have been corrected onboard already.

GIM Summary: All observations in the *HST* archive have had either pipeline or onboard GIM correction applied. Any GO/GTO working with proprietary data acquired prior to October 1, 1991 should re-process their data to include GIM correction.

III. Dead Diode Tables

From time-to-time diodes cease functioning or are turned off due to repeated sporadic noisy behavior. When a dead diode is discovered or a diode is turned off, its identity (diode number) is added to the calibration reference file which lists all dead diodes for the detector as of a particular effective date. This file is the so-called "Dead Diode Table" or DDT. A separate DDT is maintained for each FOS detector. The effective date for the file is given the slightly misleading keyword name USEAFTER date. The DDT is used by the pipeline to determine which pixels in an FOS observation must be corrected for the missing contributions of dead diodes.

Since there can be a time interval of up to a few days between the discovery of a dead diode and the installation of a new DDT in the PODPS pipeline, it is possible that some data can be processed through PODPS without correction for recently discovered dead diodes. The characteristic signature of a dead diode has the appearance of a flat-bottomed absorption feature that is 20 pixels wide (for standard NXSTEPS=4 and OVERSCAN=5 data).

It is important that observers, or archive researchers, be aware of the possibility of uncorrected dead or noisy diodes in their data. To this end a reference guide (Instrument Science Report CAL/FOS-112, C. Taylor, also this volume) that lists the correct DDT reference file to use at any particular observation time is available. A continually updated electronic version of the relevant tables from this report is available on the Space Telescope Electronic Information System (STEIS) - (accessed via anonymous ftp to *stsci.edu*).

DDT Summary: Any GO/GTO or *HST* archive dataset may have some contamination by uncorrected dead or noisy diodes. All GO/GTOs and archival researchers should consult CAL/FOS-112 or the current electronic version on STEIS to insure that their data have been processed with the most appropriate Dead Diode Table reference file.

IV. Flat Fields

FOS flat fields are intended to account for diode-to-diode variations and, in some cases, sensitivity variations with size-scales up to approximately 10 diodes. Larger scale variations are included in the inverse sensitivity (IVS) function. A more complete discussion of FOS flat fields is given later in this volume.

Substantial flat field variations of more than 10 percent have occurred for three FOS/RED spectral elements, G160L, G190H, and G270H. These changes were noted as early as mid-1991 and resulted in a continuing program of monitoring these three spectral elements at regular intervals. Several flat field reference files have been delivered in order to characterize the changes in flat field structure as a function of time. This required the institution of time-tagged flat field reference files, e.g., the addition of an effective date for each file denoted by the header keyword USEAFTER date.

The flat field structure for the FOS/BLUE and the remaining FOS/RED spectral elements has been more quiescent. However, the introduction of a new methodology for the determination of FOS flat fields - the so-called superflat technique - has resulted in more than one set of USEAFTER dates for FOS/BLUE, as well.

As a result, there have been multiple deliveries of flat field reference files since February, 1992. Some have been required to characterize the flat field changes, others have simply corrected errors in earlier versions, and some provide for the first time flats taken with the slit. Since the flat field reference file delivery history is quite complicated with many superseded files in the calibration database, a reference guide (Instrument Science Report CAL/FOS-090, C. Keyes and C. Taylor) that lists the *currently recommended* best flat field reference file to use for any particular combination of detector/disperser/aperture for any observation time is available. A continually updated electronic version of the relevant tables from this report is available on STEIS. The hardcopy version of this report also provides short descriptions of each of the major flat field programs and their limitations.

In late October, 1993, new superflat calibration observations were obtained for FOS/RED. Pending successful analysis of this data, new, higher-quality flat fields will be possible not only for Cycle 3, but for many earlier USEAFTER epochs, as well. The

STEIS listing will be updated and a general announcement to the GO community will be made when these new flats are available.

Flat Field Summary: For FOS/RED the *HST* archive is completely re-processed with the currently recommended flat field reference files for the date of observation. Any GO/GTO working with FOS/RED data obtained earlier than February 15, 1993 should consult CAL/FOS-090 or the current electronic version on STEIS and re-process their observation. For FOS/BLUE any archive or proprietary observation obtained earlier than May 1, 1993 may need re-processing - consult CAL/FOS-090 or the current electronic version on STEIS.

V. Absolute Photometric Sensitivity (IVS)

Temporal changes in absolute photometric sensitivity have been noted for all FOS/BLUE and for several FOS/RED spectral elements.

The correction for absolute photometric sensitivity of the combination of detector/disperser/aperture is made in the CALFOS pipeline by application of the appropriate Inverse Sensitivity reference file (the so-called IVS file). To date only one delivery of recommended IVS files exists. These files were delivered in March 1992, were based on observations of spectrophotometric standards made between 1991.0 and 1992.1, replaced all previous deliveries, and have been applied to all observations taken to the present time. An analysis of possible temporal correction algorithms is ongoing.

Although there is only one *recommended* set of IVS reference files, there are, as for the flats, many superseded reference files in the calibration database. Therefore, a reference guide (Instrument Science Report CAL/FOS-093, C. Taylor and C. Keyes) that lists the correct IVS reference file to use for any particular combination of detector/disperser/aperture for any observation time is available on STEIS.

IVS Summary: The *HST* archive is completely processed with the March 1992 IVS reference files. Any GO/GTO working with proprietary data obtained earlier than April 1, 1992 should consult CAL/FOS-093 or the current electronic version on STEIS and re-process their observation.

VI. Background

The CALFOS pipeline correction for particle-induced background was not scaled according to the ambient geomagnetic field at the time of observation until August, 1991.

Background Summary: All observations in the *HST* archive have been re-processed to include scaling of the particle-induced background. Any GO/GTO working with proprietary data acquired prior to August 1, 1991 should re-process their data.

VII. Scattered Light

No pipeline correction exists at present for the removal of scattered light which is known to affect a number of FOS detector/disperser combinations, among them FOS/BLUE G160L, G130H, G190H, and G270H, and FOS/RED G160L, G190H and G270H. Several important presentations on this problem will be made in this session, a detailed discussion will follow in the FOS Working Group session, and several specific recommendations will be provided in the Workshop summary. Several detailed discussions on this problem are presented elsewhere in this volume.

Table 1: Observation Processing Status

Calibration Operation	Non-Proprietary or Archivist	Original Observer: GO/GTO
GIM	Archive is correct	before 1 Oct 1991: re-process after 1 Oct 1991: OK
Dead Diodes	use CALFOS-112	use CAL/FOS-112
Flat Fields [a]	FOS/RED: Archive is correct FOS/BLUE: before 1 May 1993 use CAL/FOS-090 after 1 May 1993 Archive is correct	FOS/RED: before 15 Feb 1993 use CAL/FOS-090 after 15 Feb 1993: OK FOS/BLUE: before 1 May 1993 use CAL/FOS-090 after 1 May 1993: OK
IVS [a,b]	Archive is correct	before 1 Apr 1992 use CAL/FOS-093 after 1 Apr 1992: OK
Background [a]	Archive is correct	OK

a. improvements may occur - expected 1 Jun 1994
b. paired and barred apertures: before 1 Mar 1993 - uncertain calibration; after 1 Mar 1993 unity file applied

References

Keyes, C. and Taylor, C., 1993, Instrument Science Report CAL/FOS-090.
Taylor, C. and Keyes, C., 1993, Instrument Science Report CAL/FOS-093.
Taylor, C., 1993, Instrument Science Report CAL/FOS-112.