

IUE Calibration Progress Report
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This report summarizes the highlights of recent calibration work.

I. The IUE Point Spread Function (PSF) at large negative focus values.

Due to the accelerated degradation of the solar arrays in the last year, operations at very negative telescope focus step will occur more frequently. Previous studies (Cassatella et al. 1985, *Astr. Ap.*, 144, 335), indicate that the PSF of low-dispersion spectra is optimum (i.e. lowest) at focus values from -3 to -1, and begins to degrade significantly at more positive values. However, until recently no calibration spectra have been obtained at focus steps more negative than -3, and it has been assumed that the PSF becomes larger again at large negative values. A number of calibration spectra obtained with more negative focus values have been analyzed by fitting Gaussian profiles across the spectra in the direction perpendicular to the dispersion. The width of the spectrum is specified by the FWHM of the Gaussian profile. Surprisingly, it has been found that the FWHM of both LWP and SWP spectra either decreases slightly or remains constant as the focus goes from -3 to -8. Additionally, the SWP and LWP images taken on an emission-line star (V1016 Cyg) indicate that along the dispersion no significant broadening is experienced by the PSF, as measured by the line equivalent widths, for focus step between -3 and -8. Thus, it appears that long exposures can be obtained at high beta angles without substantial degradation of the telescope PSF.

II. LWP Sensitivity Degradation Study.

The LWP degradation study discussed in the previous Calibration Progress Report has been completed. Four hundred low dispersion spectra of the five IUE standard stars were used in the analysis. The spectra were divided into six month bins in time and 25 Å bins in wavelength. For each bin a degradation ratio, i.e. the ratio of the average flux in the bin to that of the reference flux in the 1984.5 bin, was calculated. Tests on images of the same star taken over a large span of time have shown that the linear fits to the degradation ratios give a good correction, even in the crude approximation of applying the same correction to all wavelengths in a given 25 Å bin. The values are also consistent with the routine sensitivity monitoring data (Garhart and Teays 1989, *IUE NASA Newsletter*, No. 40, p. 54). It was clear that for images taken after early 1984, the degradation has been essentially linear, for a given wavelength. The coefficients of these linear fits have been determined for each wavelength band. Tests were also conducted with a smaller wavelength bin of 5 Å, but the LWP camera proved to be too noisy to derive reliable degradation ratios in this smaller bin size.

These results were presented at the November 1989 Three Agency Coordination Committee meeting, and accepted. This study, including a table of the degradation ratios, appears in an article by Teays and Garhart in this IUE Newsletter.

III. New High Dispersion Record to MEHI File.

A high resolution absolute calibration will soon be implemented in IUESIPS. The high dispersion absolute calibration is achieved by multiplying the low dispersion inverse sensitivity function $S^{-1}(w)$ by the high resolution function $C(w)$. The value of each function (S and C), at each wavelength point, is determined by interpolation between individual entries in

a table. The interpolated values are then multiplied by the ripple-corrected net fluxes to give the absolutely calibrated high dispersion net spectrum, i.e.,

$$F(w) = S^{-1}(w) \times C(w) \times FN(w)$$

where,

$F(w)$ is the absolutely calibrated net spectrum
 $S^{-1}(w)$ is the low resolution inverse sensitivity function
 $C(w)$ is the high resolution calibration function
 $FN(w)$ is the ripple corrected net spectrum

The resulting absolutely calibrated net spectrum is given in time-integrated flux units, analogous to the low dispersion MELO record which give fluxes in units of $\text{ergs cm}^{-2} \text{ s}^{-1} \text{ \AA}^{-1}$. Division by the correct exposure time is left to the user. The high dispersion absolute calibration is taken from Cassatella et al. (1988, *ESA IUE Newsletter*, No. 31, p. 7, and reprinted in this Newsletter).

For the LWP camera, the high resolution calibration is still based on the $C(w)$ values derived from the old LWP-ITF1. Since the $C(w)$ values are largely independent of ITF and the $S(w)$ values were calculated with the new ITF, in theory, the high dispersion LWP calibration should not be strongly affected by the change in ITF. However, it should be noted that the current LWP ripple correction suffers from some problems associated with a slight misalignment of the extraction slit over one portion of the camera faceplate. Until this problem is solved it is not feasible to derive a new ripple correction and $C(w)$ values. Further work in this area has been suspended in order to devote the limited IUE resources to solving this problem in the final archives.

The additional absolutely calibrated record will be added to the Merged Extracted High Dispersion (MEHI) file on the GO tapes produced by IUESIPS. Currently, for each order, the MEHI file consists of the scaled wavelengths, epsilon values, gross spectrum, background, net spectrum, and net ripple-corrected records. The additional record will be added after the net-ripple corrected record. Detailed descriptions of the tape format and processing steps are discussed in Martin (1988, *ESA IUE Newsletter*, No. 31, p. 25 and reprinted in this Newsletter). The new record will be implemented in the IUESIPS production processing when final consistency checks are completed. Note that this high dispersion absolutely calibrated record was implemented in IUESIPS at VILSPA on December 22, 1987.

IV. New FES Reference Point.

At the time when a new S/C operations procedure was installed on January 22, 1990 a new FES reference point was also implemented (old position = -16, -208, new position = -144, -176). The old FES reference point suffered from fatigue due to the extensive positioning of objects at that location, necessary for standard target acquisition. Preliminary calibrations of the FES counts at the new reference point indicated that on the average such counts are brighter by 22% (135 data points) for fast track/overlap stars and by 9% (39 data points) for underlap stars compared with the old reference point. A more extensive calibration of the photometric efficiency of the new reference point will be presented in the near future.

V. Mapping of the FES No. 2 Aperture Plate.

In preparation of the future implementation of the one-gyro attitude control system, it will be necessary to accurately know the locations and spatial extents of the focal slots, fiducial lamps and low reflectivity patch. Target acquisition under the one-gyro system requires the

tracking of the FES along a prescribed path in order to slew the target into the appropriate aperture. Therefore, the holes in the aperture plate must be avoided so star presence can be properly detected by the FES. The measurements of all the 8 focus slots, 5 fiducial lamps and of the low reflectivity patch have been completed in the operational FES No. 2 (Webb and Shrader 1989, *Proceedings of the Three-Agency Meeting*, November). An estimate 40 hours of S/C maintenance time was used to accomplish this project. Future work will require the coding of the found positions into the one-gyro S/C operations procedure.

VI. Camera Artifacts.

The study of camera features that mimic spectral features or "camera artifacts" in low-dispersion SWP, LWP and LWR has been completed. More than 400 sky background spectra, TFLOODS and UVFLOODS were analyzed for this study. It was found that the camera artifacts are strong in spectra characterized by long exposure times because they scale in time-integrated flux with the background level, which increases during the exposure due to camera phosphorescence. These artifacts could not be detected in spectra obtained from short, direct exposures of flat-field lamps or standard stars. The artifacts resemble emission lines and the most visible are at 1279, 1288, 1491, 1533, 1663 (O III) and 1750 Å (N III) for the SWP, and at 2256, 3087 Å for the LWR. The LWP camera presents higher noise shortward of 2400 Å and the artifacts such as the one at 2898 Å appear to be of lower relative intensity. A paper entitled "Camera Artifacts in IUE Low-Dispersion Spectra" by D.M. Crenshaw, O.W. Bruegman, and D.J. Norman presenting these results are published in the April issue of the *Pub. Astron. Soc. of the Pac.*, 102, 463.

VII. Background Correction in High-Dispersion Spectra.

The long-standing problems of the high-dispersion absorption features –mostly interstellar lines– of yielding negative fluxes and systematically larger equivalent widths compared with other UV missions (e.g., Copernicus) have been reconsidered for a correction scheme. Eight SWP and three LWP high-dispersion images of the star μ Col were recently secured at different offset reference points in order to improve the background correction used in extracting high-dispersion IUE spectra. Since the correctly re-calibrated IUE data in turn will help to calibrate GHRS data, Fred Bruhweiler, GHRS staff member, has accepted the responsibility to acquire a high S/N data set, analyze and propose a correction algorithm for the SWP and LWP cameras, analogous to the one suggested by Bianchi and Bohlin (1984, *Astr. Ap.*, 134, 31).

VIII. Absolute Calibration Plans for the Final Archives.

At the recommendation of the November 1989 User Committee, work on the derivation of 1984-85 SWP and LWR flux calibrations using the current processing system was suspended due to manpower limitations and to the desire to not change the flux calibration so close to the start of the reprocessing effort. New low dispersion absolute calibrations using the 1984-85 epoch ITF's and calibration data are available for the SWP, LWR, and LWP cameras which were derived with the current processing system (Oliversen, Report presented at the June 1987 IUE Three-Agency Committee meeting; Crenshaw and Park, Report presented at the May 1989 IUE Three-Agency Committee meeting; Cassatella 1988, *NASA IUE Newsletter*, No. 35, p. 225). However, it was felt that these calibrations could not be used "as-is" for the Final Archives and would need to be re-derived for several reasons. First, new ways to improve the accuracy of the determination of effective exposure times (and thus the accuracy of the standard star fluxes) were not fully understood at the time of the

initial derivation of the "new" flux calibrations and should be included in the rederivation. Second, it is expected that the improved noise characteristics of the new processing system will improve the accuracy of the calibration in the extreme wavelength regions where the standard star data are weak. Third, additional standard star spectra (especially for the LWP) should be used in the rederivation of the flux calibrations. Fourth, new techniques such as those recommended by the recent FADC should also be investigated. Lastly, it was felt that the SWP and LWP calibrations should be developed at the same time in order to ensure consistency in the spectral overlap region between the two cameras.

Detailed plans for the derivation of the low dispersion absolute calibration are being developed by A. Cassatella of VILSPA, with input from the calibration staff here at GSFC. It was felt that a detailed plan was necessary to ensure coordination amongst the various groups who will be working on the flux calibrations. There is little time in the development schedule for mis-communication! The low dispersion absolute calibration plan will be finalized no later than September 1990, before the recalibration work begins.

Due to manpower limitations the derivation of new flux calibrations has been divided up amongst members of the Three-Agencies. VILSPA will be responsible for deriving the LWP and SWP low dispersion inverse sensitivity curve using the 1984-85 epoch data. NASA will be responsible for deriving the LWP and SWP low dispersion sensitivity degradation correction routines. SERC will be responsible for the high dispersion ripple correction.

The low dispersion flux calibration for the final reprocessing is expected to be significantly improved compared to the original 1978-79 SWP and LWR calibrations. In addition to the improvements noted above, the following improvements are possible: (1) The fluxes will be given in units of $\text{ergs cm}^{-2} \text{s}^{-1} \text{\AA}^{-1}$ rather than time-integrated fluxes. This is not done in current IUESIPS because the determination of the correct exposure time is not straight-forward. However, the exposure time is one of the core data items which will be verified for the Final Archive and can thus be accessed during reprocessing. (2) The new flux calibration data set is more complete/extensive than the original 1978-79 data set. Overexposed spectra are also available to improve the calibration in the extreme wavelength regions. The enlarged data set helps to improve the reliability of the new calibration. (3) The effects of the relative responses of point-source and trailed spectra will be corrected for. This effect was not fully appreciated in the derivation of the original calibrations and can be significant (up to $\sim 5\%$). (4) The fluxes should be corrected for camera sensitivity degradation. This effect can be quite significant - up to 15% for the LWR camera during its useful lifetime.