RESULTS OF BASIC IMPROVEMENTS TO THE EXTRACTION OF SPECTRA FROM IUE IMAGES

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ABSTRACT

Now that IUE is a mature operational satellite, the in-flight performance of the scientific instrument can be assessed. Since an additional 5 years of operations seem likely, the data reduction system is being optimized to realize the full capabilities of the observatory. Results of two methods of extracting spectra from IUE images are compared. The first method, which is presently implemented, performs a geometric correction of the image followed by a photometric correction. The spectral data are then extracted using a slit with an effective width and sampling interval of 2.4Å for the SWP camera and 3.7Å for the LWR camera in low dispersion. The second method performs the photometric correction without doing a geometric correction. The spectral data are then extracted from the photometrically corrected image by an extraction slit, which follows the spectral orders in the non-geometrically corrected space, with an effective width and sampling interval 1/2 that of the present method. In the first method, the non-linear data are subjected to resampling in the geometric correction procedure. Since the new method omits this resampling, and uses an effective slit one half as wide, the photometric integrity is preserved and the resolution is increased. For example, a pair of emission lines separated by two slit widths are blended in the first method but are clearly resolved in the second method. The noise in extracted spectra is increased by about 1.4, as expected on the basis of slit widths. However, the guest investigator will soon have the option of binning the data to reduce noise or co-adding multiple exposures to obtain a significantly improved resolution. The new magnetic tapes will remain essentially unchanged, except for longer record lengths necessitated by the increased number of spectral sample points.

PRESENT METHOD

The first processing step for each image is a geometric correction of the raw image performed by means of bilinear interpolation within a square grid of 169 fiducial marks (reseaux). This correction involves a resampling of the original image, resulting in some degradation of resolution. Since this resampling is done in the (non-linear) DN space of the raw image, some photometric error is also introduced (ref. 1). The photometric correction of the image is effected by means of a pixel-by-pixel intensity transfer function. The spectral data and background data are then extracted with slit widths of 1.4 pixels. The background is smoothed with a triangular filter before subtraction to obtain the net spectrum.

NEW METHOD

In the new method the resampling of the raw image is avoided by performing the photometric correction without prior geometric correction. Using the square grid of 169 reseaux the correct ITF can be associated with each pixel. Normally the raw data pixel will have a position between four available ITF curves. Each of these ITF's is applied to the pixel DN value, and bilinear interpolation of the four values yields the flux value. To extract the spectrum from the photometrically corrected image it is necessary to use dispersion constants for a geometrically corrected image. This is done by computing the position of the points, shown in Figure 1, in "geomed" space and then using the information from the reseaux grid to compute the position in "ungeomed" space. The flux value assigned is the bilinear interpolation of the flux values of the four pixels around the ungeomed position. Neighboring points are added in the spatial direction giving a table of flux versus wavelength and spatial position. The gross and the background spectra are then obtained by summing the appropriate regions in the spatial direction (Figure 2). In the new method, points within a reseau are not used for background determinations. The background is then smoothed using a median filter (for removal of noise spikes) followed by a triangular filter.

RESOLUTION ENHANCEMENT

The most pronounced improvement of the new method is the increase in apparent resolution. Figure 3 shows a region of a platinum wavelength calibration spectrum extracted with the old and new method. The pair of spectral lines at about 2815Å is unresolved with the old method but is clearly resolved with the new method. The increased resolution is due to not resampling the image for geometrical correction and to using an extraction slit with an effective width one half as wide.

BACKGROUND SMOOTHING

In Figure 4 the comparison of the two background smoothing techniques is shown. Note that the reseau at about 1950Å has already been removed before smoothing in the new method. Remains of the reseau in the background of the old method still show after smoothing. The new method of smoothing does a much better job of removing blemishes and fine structure in the background without harming the general curvature.

NOISE

The noise levels for a point source and a trailed spectrum were established using 60% flood images. To achieve approximately the same flux as an astronomical source, a slit height of 2.5 lines (3.5 pixels) of extracted data was used for a point source, and of 10 lines was used to simulate a trailed spectrum. The noise statistics for the SWP and LWR images are shown in Figure 5 and 6 as a function of wavelength.

REFERENCES

1. Turnrose, B. and Harvel, C., International Ultraviolet Explorer Image Processing Information Manual.

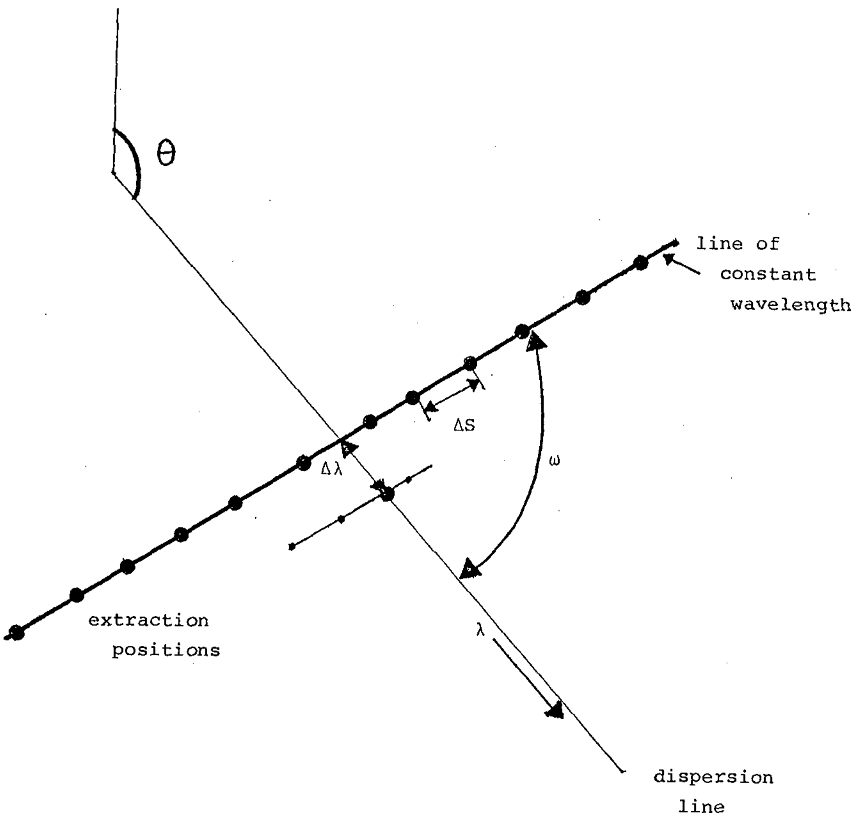

Figure 1 - Spatial information extraction.

ΔS - spacing of extraction positions in the spatial direction (.707 pixels)

Δλ - spacing in the wavelength direction

Θ - angle of the dispersion line

ω - angle of the line of constant wavelength from the dispersion line

● - extraction positions

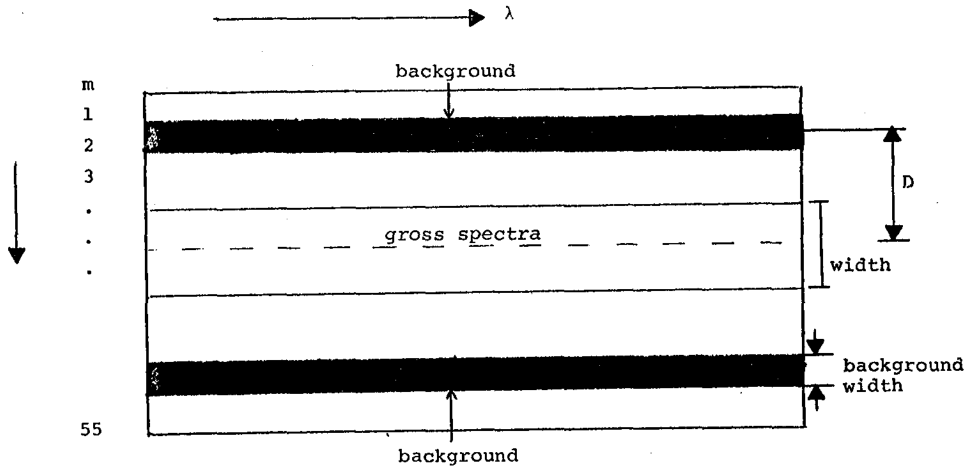

Figure 2 - Extraction of the gross and background spectra from the spatial information.

m - spatial position, i.e. line number of extracted data

D - distance of background extraction from the center of the dispersion line

WIDTH - width of the region to be summed vertically to obtain gross spectrum or background

Note that wavelength (λ) increases to the right.

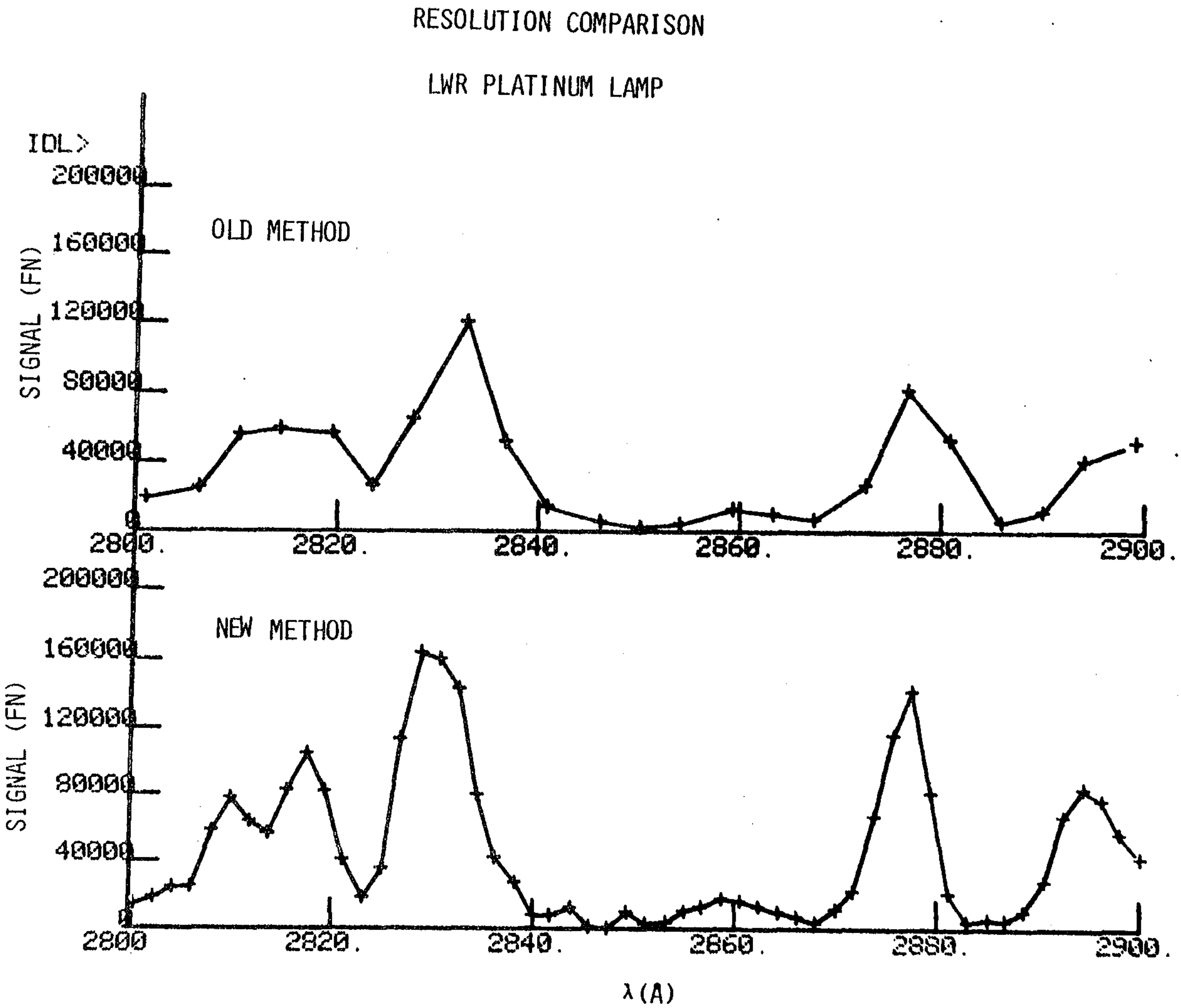

Figure 3 - Comparison of a portion of a LWR platinum lamp spectrum extracted with the new and old extraction methods. The symbol "+" marks extraction positions, i.e. data points that are on the guest observer data tapes.

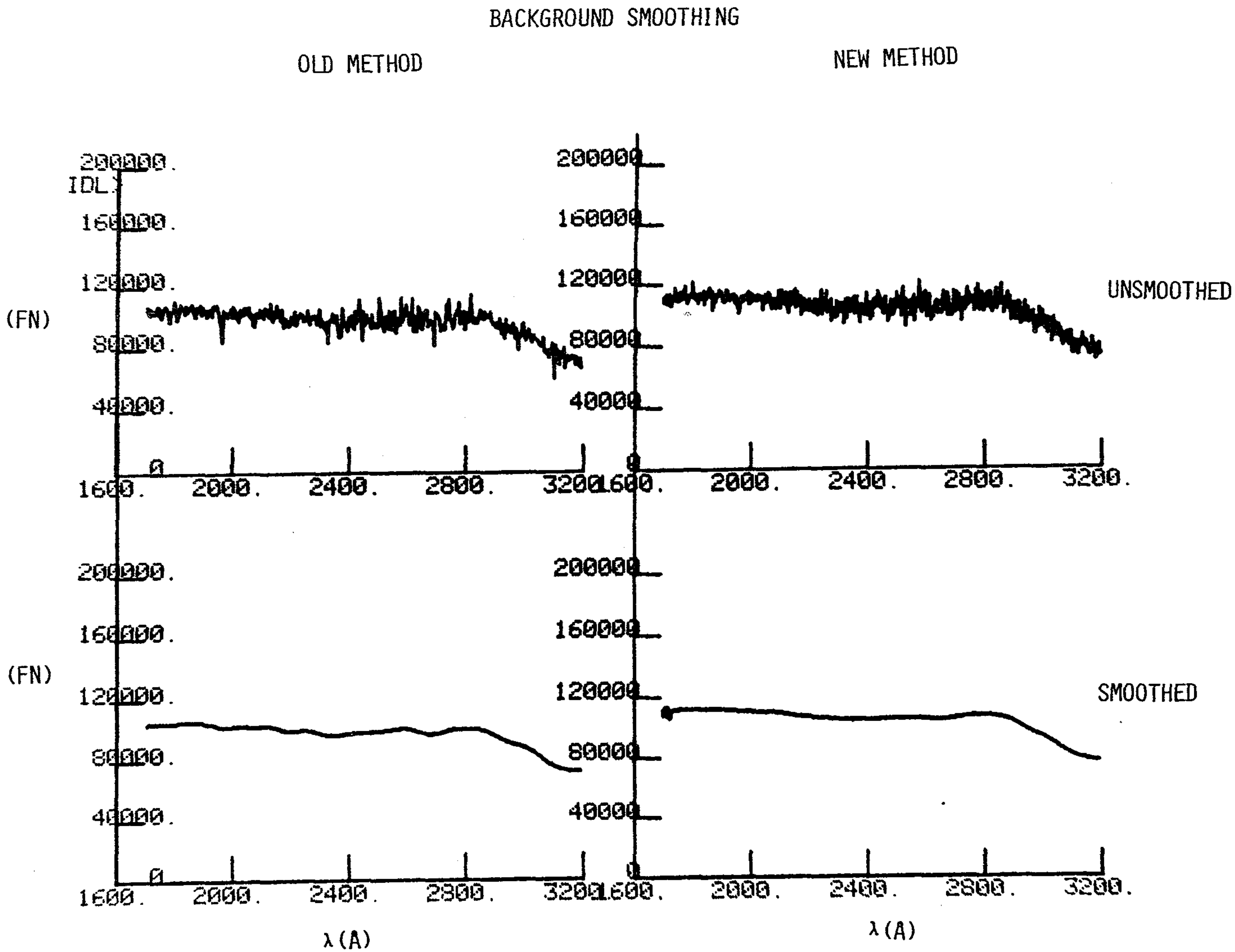

Figure 4 - Comparison of the treatment of the background data using the old and new techniques. The unsmoothed trace has the reseaux removed in the new method. The main difference in the two smoothed curves is the application of a median filter in the new method.

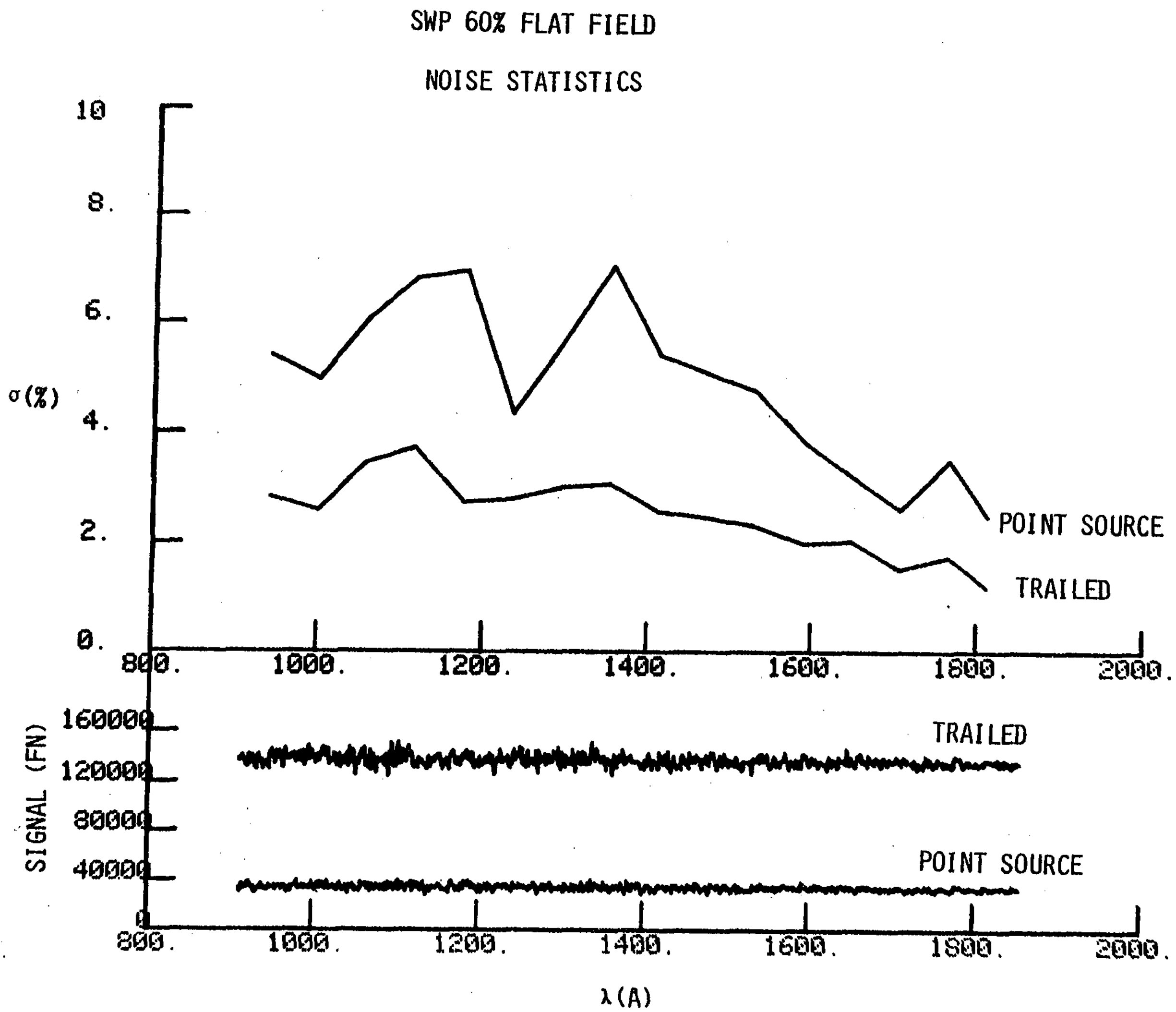

Figure 5 - Noise statistics of artificial spectra extracted from a SWP 60% flat field with extraction slits equal to the FWHM of the widths of trailed and point sources. The values of the 1σ noise statistics were the scatter among the individual 50 points of bins of the signal.

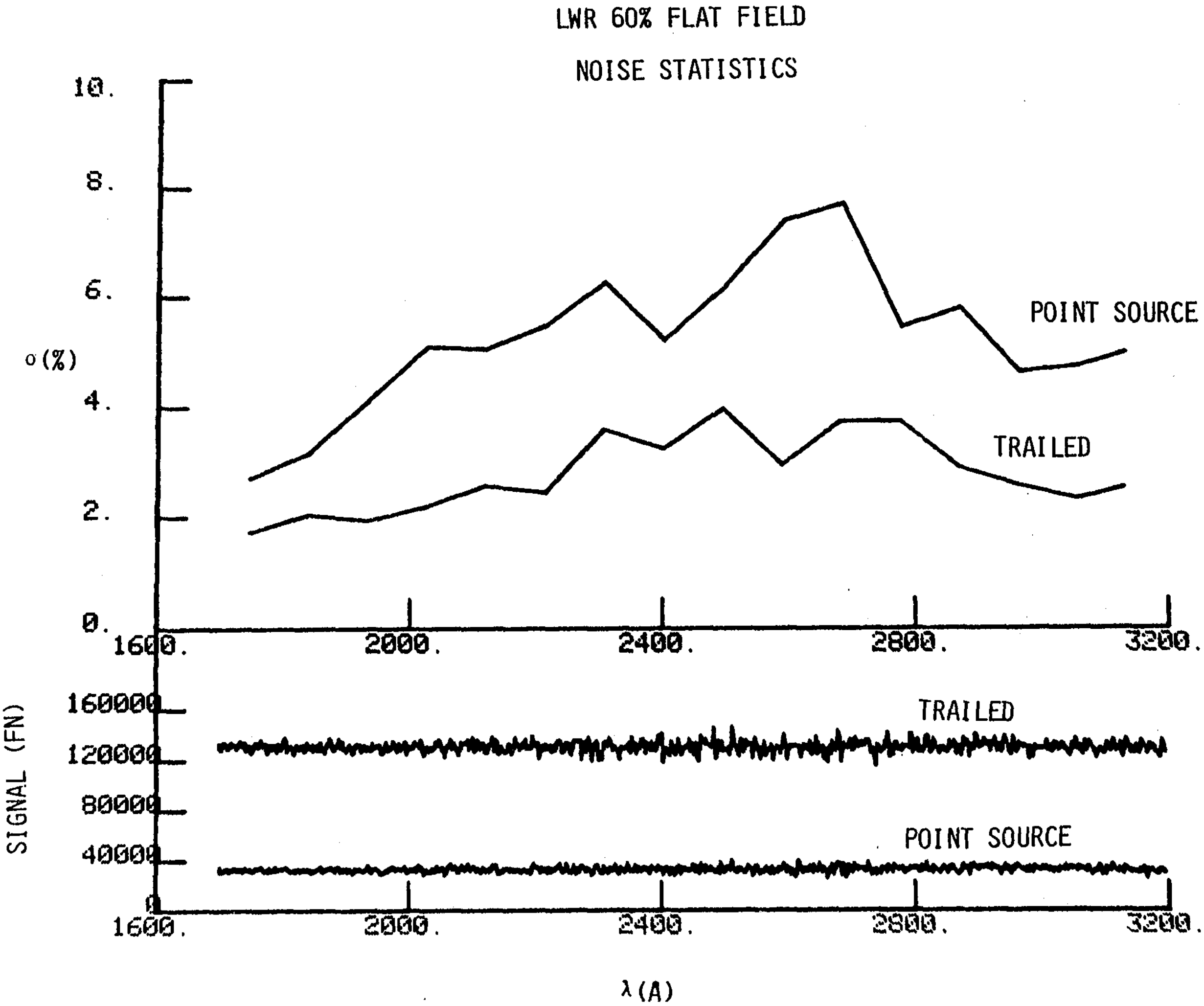

Figure 6 - Same as Figure 5 for the LWR camera.