IUE DATA REDUCTION

X. Planned Changes to the Background Smoothing Algorithm

Memos VI-IX of this series have described various aspects of planned changes to the basic IUE image processing system which collectively define a new reduction era to be implemented over roughly the next six months. This memo discusses changes which will be made to the algorithm for deriving the background for spectra under the new system.

Currently, the background spectra generated by the extraction routines EXTLOW and DATEXTH are smoothed by a running-average filter to suppress noise before subtraction from the gross spectra. A 15-point running average of the background is first calculated, and then that averaged spectrum is run through a second 15-point running-average filter. The program which performs this filtering is called SMOOTH, and the two successive executions of SMOOTH on the background spectrum mimic the effect of a single pass of a triangular-weighted filter of 30 points total width. Implicit in this approach is the assumption that features in the background spectrum on scales smaller than the filter width are spurious. Particularly in the case of high dispersion, where the background spectrum (more accurately, an "interorder" spectrum) is just an average of a one-pixel measurement taken to either side of the echelle order, such a noise-suppression technique is both necessary and justifiable. In low dispersion, the background spectrum is a multi-pixel measurement covering roughly one-half to one-third of the number of pixels used to define the gross spectrum, depending on whether "point source" or "extended source" reduction is elected. Here the background is smoothed so as not to artificially increase the noise level in the net spectrum, since the photometric correction procedure (reduction to flat fields) is designed to leave only high spatial frequency noise in regions of no spectral signal.

The biggest difficulty with the current smoothing procedures is that the running mean filtering simply smears out the input data, so that points which are clearly artificial, such as reseau marks, chronic "bright pixels", and radiation events, are folded into the smoothed background in a "diluted" manner rather than removed cleanly: for example, a reseau mark appearing originally as a deep depression 2 or 3 extraction points wide is in effect transformed into a broad, shallow depression more than 30 points wide. This problem is exacerbated by the poor concept of the current filtering: as the filter window is passed along the data, filtered (replaced) points are used in the computation of subsequent window means, so that features propogate, at low levels over very many points in the output.

In order to eliminate these problems, the new reduction system will first process the extracted background signal with a "median filter" and then process the result with a double pass mean filter. A mean filter replaces the central sample within the filter "window" (the set of neighboring points falling within the filter width) by the mean of the samples in the window. A median filter replaces the central sample of the window by the median of the samples within the window. A median a filter has the desirable property that discrepant features (i.e., high points or low points) which are narrower than one-half of the filter width are eliminated (Reference 1).

By using a median filter to preprocess background spectra before a final smoothing by a triangular filter, the effects of localized artifacts such as were mentioned above (reseaux, bright spots, radiation events) may be eliminated and a more faithful background level obtained. Note also that by using a sufficiently large median window, as we plan to do, the effects of larger-scale artifacts such as spill-over of geocoronal Lyα into the background region on long-exposure SWP spectra will be suppressed as well. We propose to use a median filter which is the spectral equivalent of 31 current extraction points wide, followed by a double-pass mean filter (which does not use the replaced values in the window calculation of subsequent points), each pass of which is the spectral equivalent of 15 current extraction points wide; because the new reduction system will sample the data at twice the frequency of the current system, the actual widths will be $W_{median} = 63$ and $W_{mean} = 31$ in terms of new extraction samples.

Figures 1 and 2 illustrate the differences between the current and proposed smoothing methods for two separate SWP background spectra extracted under the current software system. Figure 1a shows a large-aperture background spectrum with strong Lyα contamination overlaid by the smoothed spectrum obtained with the current running average method. Note that the Lyα spillover is merely smeared out by the current method. Figure 1b shows the same background spectrum overlaid by a smoothed version obtained with the proposed median/triangular combination filtering discussed above (31-pt median followed by double-pass 15-pt mean filter). Under the new smoothing algorithm, the Lyα contamination is removed cleanly.

Figures 2a,b,c show a noisy, low-level SWP background spectrum treated rather similarly. (A 35-pt median happened to be used in creating Figure 2c instead of 31-pt median; the results are insensitive to this difference, however). Some subtle differences between the current and proposed smoothings are evident from Figure 2. Note that the median-plus-mean filtered spectrum is smoother than the mean-only filtered spectrum. Note also that there are some systematic differences between the two results: e.g., the median-plus-mean filtered version runs through the data between 1200 and 1300Å at a noticeably lower level, and through the sharp depression at 1500Å at a higher level. These are regarded as examples of the desirability of the median filter.

In Figure 3 we illustrate for completeness an example of an alternatire method of background smoothing suggested for use in low dispersion by the VILSPA IUE Project: a low-order polynomial fit to the background spectrum (not the same spectra as shown in Figures 1 and 2), iterated to reject points departing from the fitted curve by more than a threshold tolerence. This method has some of the attributes of the median-plus-mean smoothing, namely rejection of localized features and generation of a very smooth output, but the calculations required are prohibitive in the case of high dispersion and they inevitably impress potentially undesirable curve-fitting effects, such as forcing a certain number of inflection points in the fit. In the interest of efficiency and flexibility, therefore, we elect to utilize the median-plus-mean smoothing technique in both dispersion modes under the new reduction system.

B. Turnrose

C. Harvel

R. Bohlin

October, 1979

References

1. Pratt, W., 1978, <u>Digital Image Processing</u>, (New York: Wiley Interscience).

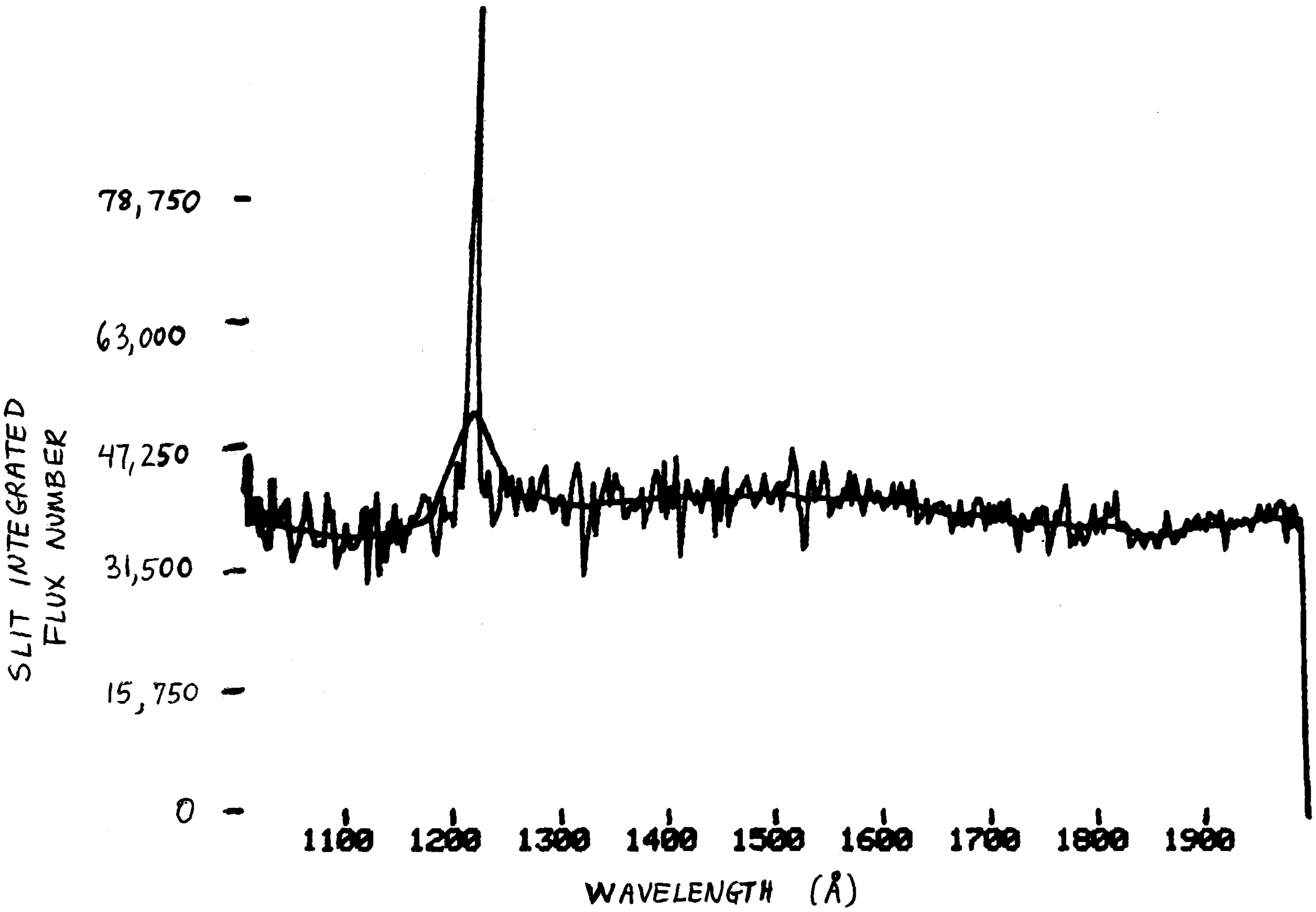

FIGURE 1a - SWP 6160 background, overlaid by a version obtained with the current production smoothing algorithms.

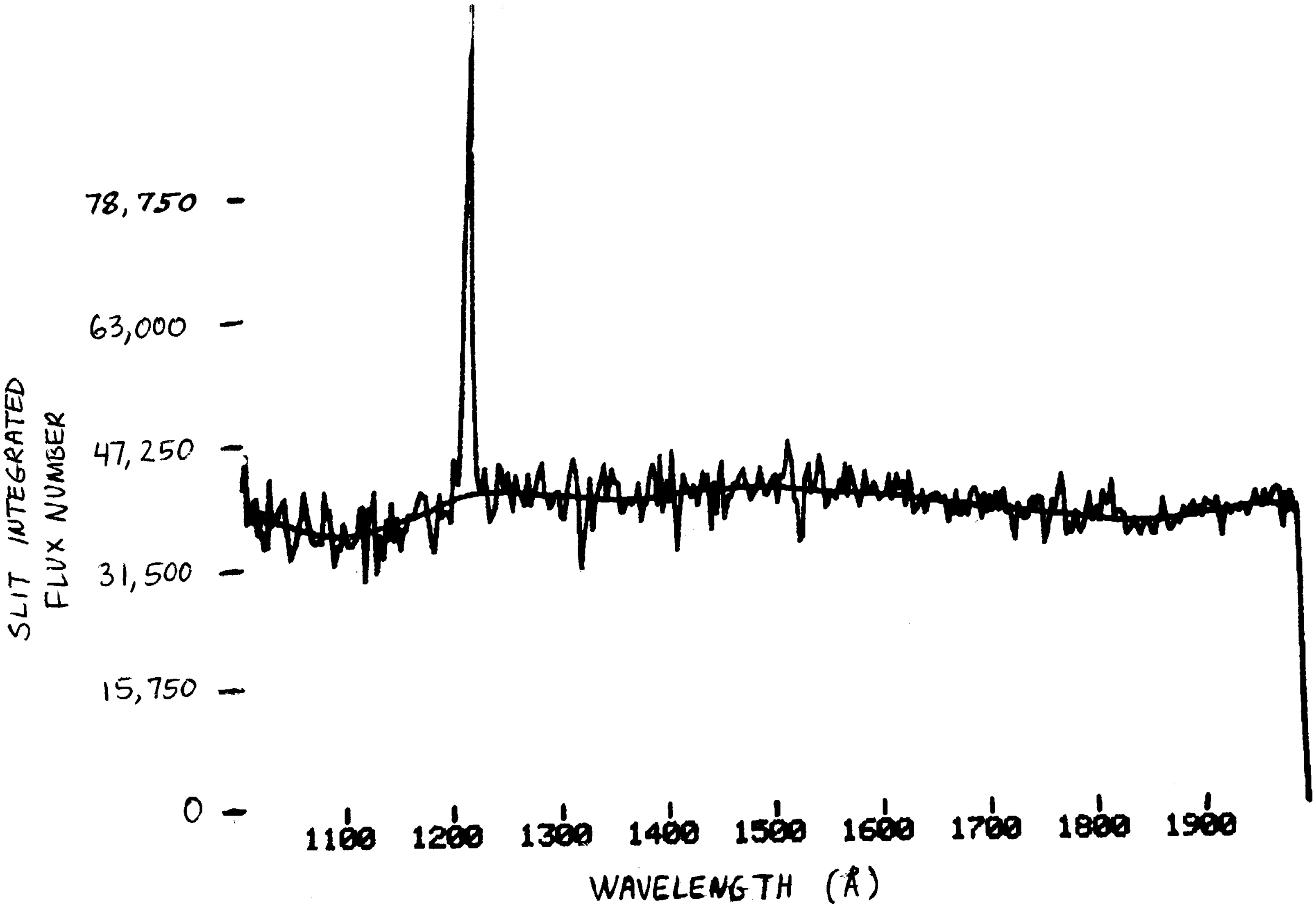

FIGURE 1b - SWP 6160 background, overlaid by a smoothed version obtained with proposed new median/mean filtering algorithm.

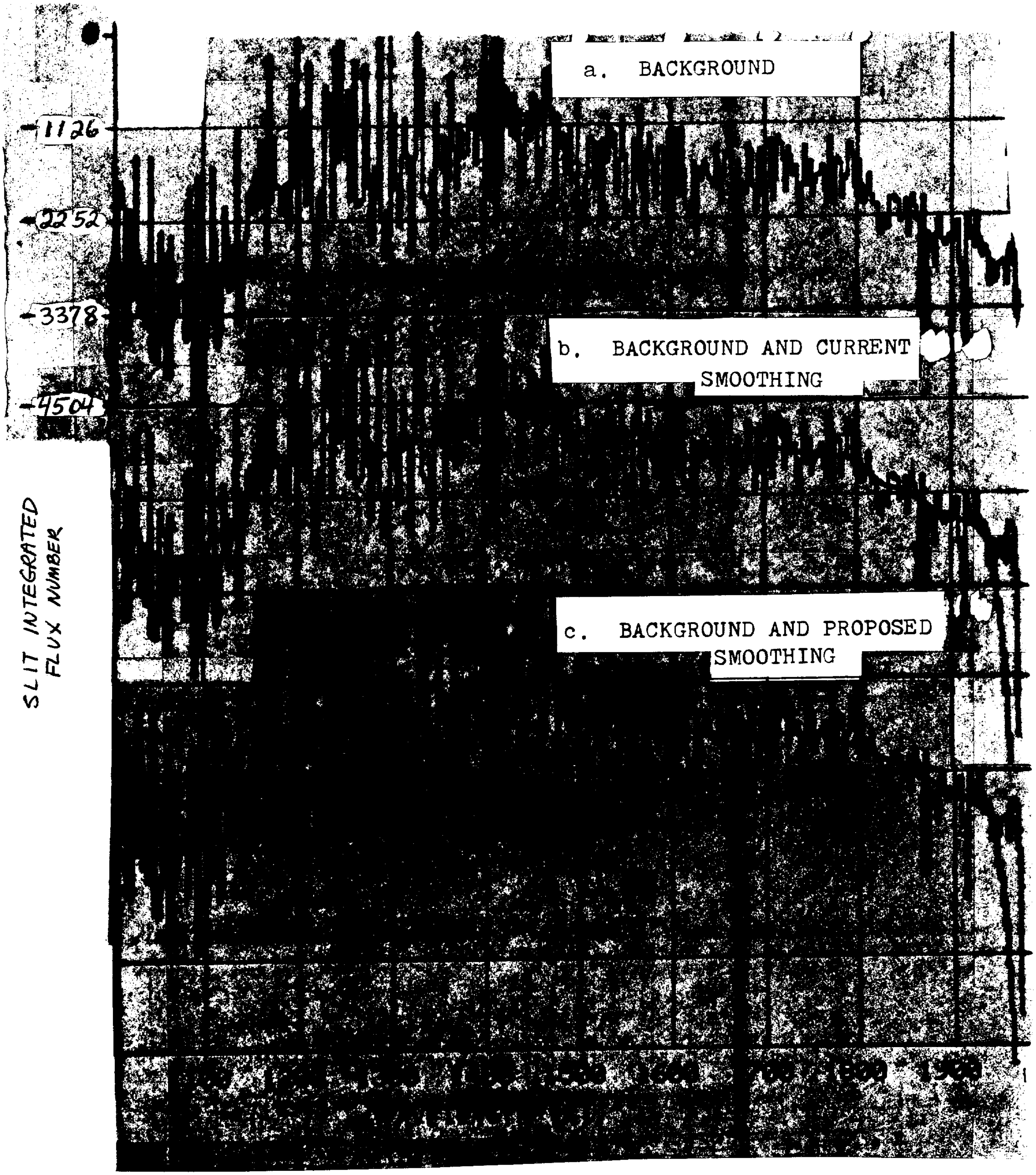

FIGURE 2 - SWP 5644 background. Ordinate scales for b and c are arbitrarily offset.

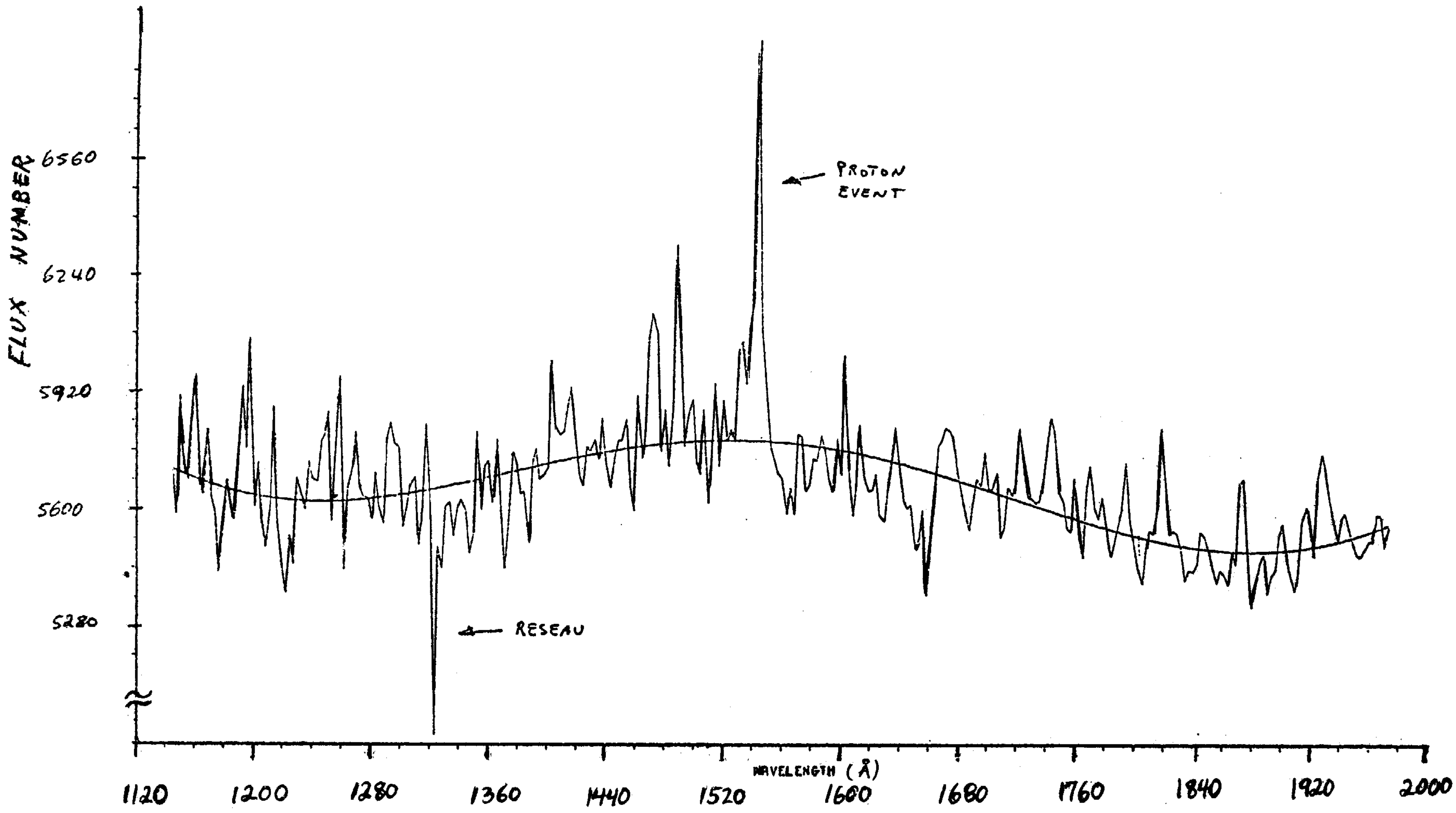

FIGURE 3 - VILSPA polynomial fit to low dispersion SWP background.