TV Monitoring of the F8 Detector Red Sensitivity
(Test Segment YMONTHLY)

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Abstract

Spectra obtained with the G780H grating and the internal cross-strapped calibration lamp indicate that the red sensitivity of the F8 detector is not stable and may be dependent on its temperature history. Comparison of pre-TV spectra with similar data obtained in December 1985 show a wavelength dependent drop of ~ 40% at 7400Å and ≤ 10% at 6300Å, but spectra obtained after the detector had been operated for some time in the relatively cold (~ 5 C) TV environment indicate a return of the red response to about the December 1985 values. An additional measurement in August 1986, after the FOS sat in ambient conditions for about 7 weeks following TV, shows a recurrence of the red response degradation.

I. *Introduction*

The F8 Digicon has a history of degradation of red sensitivity, as determined by QE measurements made at EVSD at various times throughout its build-up into a flight detector unit. The test segment YMONTHLY was created in order to continue to monitor the health of this detector after its installation, in December 1985, in the FOS. A measurement of the ion count ratio and acquisition of spectra of the internal, cross-strapped calibration lamp were included in the test. This report considers only the spectral data, which are used to infer relative red sensitivity values.

II. *Test Description*

Spectra were obtained with the G780H grating through the 0.1-PAIR apertures, on the FOS red side only. Three Y-steps, with $\sim 50\mu$ separation, were used to assure that the spectra were fully registered with the diode array (*i.e.,* no flux was lost beyond the edge of the array), and separate acquisitions were made from the upper and lower apertures. The exposures were for 2.0 sec per pixel, with the usual 4 X-steps and overscan of 5. The detector is operated at 18.75 kV for these tests, since it is expected that YMONTHLY will be run in a variety of environments, in some of which operation at the nominal 21.4 kV level might be unsafe.

Table 1 presents a log of the YMONTHLY data that have been obtained to date. The earliest spectra available for use as the baseline are those obtained as part of the wavelength calibration immediately following the F8 installation, for which only a single Y-step was used. However, since measurements of the Y-bases for each grating were made shortly before the wavelength calibration, it is almost certain that the spectra are well centered on the array. These spectra were also obtained at the nominal (21.4 kV) operating voltage, rather than the 18.75 kV used for the YMONTHLY acquisitions, but this produces a wavelength-independent QE change of only about 5%. The December 18, 1985 data have therefore been adopted as the baseline against which the succeeding spectra are compared in the following analysis.

III. *Analysis and Results*

The spectra at each of the three Y-steps were first intercompared to determine which, if any, was not fully on the diode array. Since the Y-base values for this grating and detector parameters were not well established, especially with the FOS horizontal for TV, it was often the case that some of the flux was missing from one of the three spectra; however, in all cases, at least two of the spectra through each aperture were well registered with the array. Since the observations made in each test included equal exposure through each of

Table 1
YMONTHLY Test Summary

Date	Environment	Filenames	Comments
18 Dec 1985	Amb./Install'n.	YBH0344	Baseline; 1 spectrum ea. aperture.
2 May 1986	Amb./Pre-TV	YBV0028-9	Good Y-base; all 3 spectra equal.
7 Jun 1986	Vac./TV-Cold	YCC0012-3	Third Y-S loses some flux.
12 Jun 1986	Vac./TV-Cold	YCK0012-4	Third Y-S loses some flux.
24 Jun 1986	Vac./TV-Hot	YCU0029-30	Third Y-S loses some flux.
20 Aug 1986	Amb./Post-TV	YDE0013-4	Good Y-base; all 3 spectra equal.

the two (upper and lower) apertures, and since the measurements are photon noise limited at the red end of the spectrum, the data from each Y-step that was fully on the array and from both apertures were co-added. These combined spectra were intercompared as follows: The spectra were first converted to count rates, then smoothed with a 25 pixel wide filter, cross-correlated and shifted, so that the comparison spectrum was put on the same wavelength scale as the baseline, then rebinned into 25 pixel wide bins, and finally divided, bin-for-bin, to yield the relative sensitivity as a function of wavelength. The error in the ratio due to photon noise was also calculated for each bin, and points with a 1σ error of 15% or less were plotted.

The results are shown in Figures 1 through 5, in which the summmed data from each of the YMONTHLY tests are compared with the December 1985 baseline. The wavelength-dependent sensitivity loss indicated by Figure 1, which shows the ratio of the pre-TV run of YMONTHLY to the baseline data taken 19 weeks earlier, is in reasonable agreement with the decay rates calculated from the EVSD QE measurements. Using the "half-life" values reported by Beaver (1986), we would expect to see drops of about 15% at the short wavelength end of the G780H spectrum (λ6300), and about 50% at the longest wavelengths measured (λ7500). The observed decay is somewhat less severe, especially since we expect that some of the drop is due to the lower operating voltage used in the May measurement, but agrees with the predictions, within the uncertainties due to lamp variability and decay rate determination.

The first YMONTHLY measurement made during TV indicated a remarkable reversal to the red response decay seen earlier. As shown in Figure 2, the fluxes measured on 7 June meet or exceed the baseline values. With the possible exception of the points beyond λ7400 which lie a bit lower, the ratio shows little wavelength dependence and stands at ~ 15% high. This apparent *increase* in sensitivity from the December 1985 levels is partially due to an increase in the cal lamp output at the colder TV temperatures (~ 0 C). This behavior of the lamps has been observed previously with the (very stable) F3 detector, during the thermal-vacuum testing at MMDA in 1984. Figure 7 shows the ratio of G780H spectra obtained during the "cold" operate period of TV-3 in July 1984 and in ambient conditions in August 1984. The lamp output was apparently ~ 20% greater, independent of wavelength, when it was operated at cold temperatures in TV. However, the wavelength-dependent drop in sensitivity clearly seen in the pre-TV data is no longer apparent. After correction for the expected increase in lamp flux, the detector most likely has returned to very nearly the sensitivity that it had at installation, at all wavelengths. Additional measurements made on 12 June (Figure 3.) and 24 June (Figure 4.) show essentially no change from the 7 June values, but do confirm the weak relative drop at the longest wavelengths. It should be noted that some loss of sensitivity at the extreme red end relative to that measured at ambient temperatures is expected when the photocathode temperature is reduced, due to the increase in work function at lower temperature.

The final YMONTHLY measurements were made on 20 August, after the HST was removed from the TV chamber and returned to a vertical orientation in the VATA. Approximately seven weeks elapsed between return of the spacecraft to ambient and this test. Figure 5 shows the apparent return of wavelength-dependent sensitivity decay; the response of the detector has dropped to very nearly the levels seen in pre-TV, as can be seen in Figure 6.

IV. *Discussion*

The wavelength-dependent decline in response that has been observed during most of the life of the F8 Digicon may be attributed to the evaporation of cesium from the surface of the photocathode when the tube is at room temperatures. That this process might be arrested by storage of such tubes at reduced temperatures was suspected before the TV tests. The reversal of the sensitivity decay at long wavelengths seen in TV can be understood as due to condensation of cesium that is evaporated from other parts of the tube (to which it had migrated from the photocathode) onto the relatively cold photocathode surface. Since the tube was essentially isothermal, at nearly 0 C, during periods in which the red side is not operating (the FOS heat pipes were non-operative in the horizontal orientation required for TV), this selective deposition of cesium could not occur during most of the time that the spacecraft spent in TV. However, while the charge amplifiers were turned on, a temperature differential of about 20 C was produced between the photocathode, which remained near 0 C, and the rear of the Digicon. Since most of the red side operation (~ 16 hrs.) occurred before the first TV YMONTHLY measurement, the June 7 measurement shows the greatest degree of improvement in red response. The red detector was used only for the SCT Orbit 8 tests between the 7 June and 12 June tests and between the 12 June and 24 June tests (~ 1.1 hrs. each), so we would expect little change in sensitivity, as observed, during these periods.

The sensitivity drop observed following TV to essentially the 2 May values, occurred more rapidly (in just 7 weeks in ambient) than did the same degree of decay between 18 December and 2 May (19 weeks). This may be indicative that the condensed layer of cesium that is responsible for the red sensitivity improvement evaporates more readily from the photocathode than it did originally (causing the sensitivity decline).

V. *Summary*

The YMONTHLY results demonstrate that the current red detector has an unstable photocathode, the sensitivity of which appears to be dependent on its temperature and operation history. The measurements confirm that the red response continues to degrade, as long as the tube is maintained at ambient temperature, at rates that are comparable to those inferred from the pre-installation QE measurements made at EVSD. With launch now most likely 2-3 years away, these decay rates will render the detector extremely insensitive at Hα and essentially useless at longer wavelengths when HST reaches orbit. These measurements indicate that some degree of sensitivity improvement will likely occur once the instrument is in orbit, but the extent of QE increase that we might expect remains unknown. Also unanswered are questions concerning the spatial uniformity of the photocathode response after cesium re-deposition and the stability of response that might be expected with detector cycling during normal orbital operation. We may hope to gain further insight to these questions as a result of laboratory experiments that are currently underway at EVSD, under the direction of Dr. Beaver, on the F-9 Digicon, and by the continued monitoring of F-8 with YMONTHLY. A confirmation of the absolute QT of the FOS red side is also planned for this fall, once the instrument is removed from HST and the ambient ST simulator (ASTOS) can be mounted in front of the FOS.

Reference

Beaver, E. A. 1986, *FOS Detector Status Report, delivered to FOS IDT, 18 June.*

Figure Captions

Figure 1. Comparison of the summed YMONTHLY spectra obtained on 2 May 1986, during pre-TV testing, with the baseline spectra of 18 December 1985, taken just after the F8 detector had been installed in the FOS. The red response continues to decay at approximately the same rates seen in previous EVSD QE measurements.

Figure 2. Same as Figure 1., but for the 7 June 1986 YMONTHLY data, obtained during the cold balance portion of the TV testing, after ~ 16 hrs. of red side operation in TV. The red response appears to have improved, presumably as a result of operation in the TV environment, to nearly the baseline values.

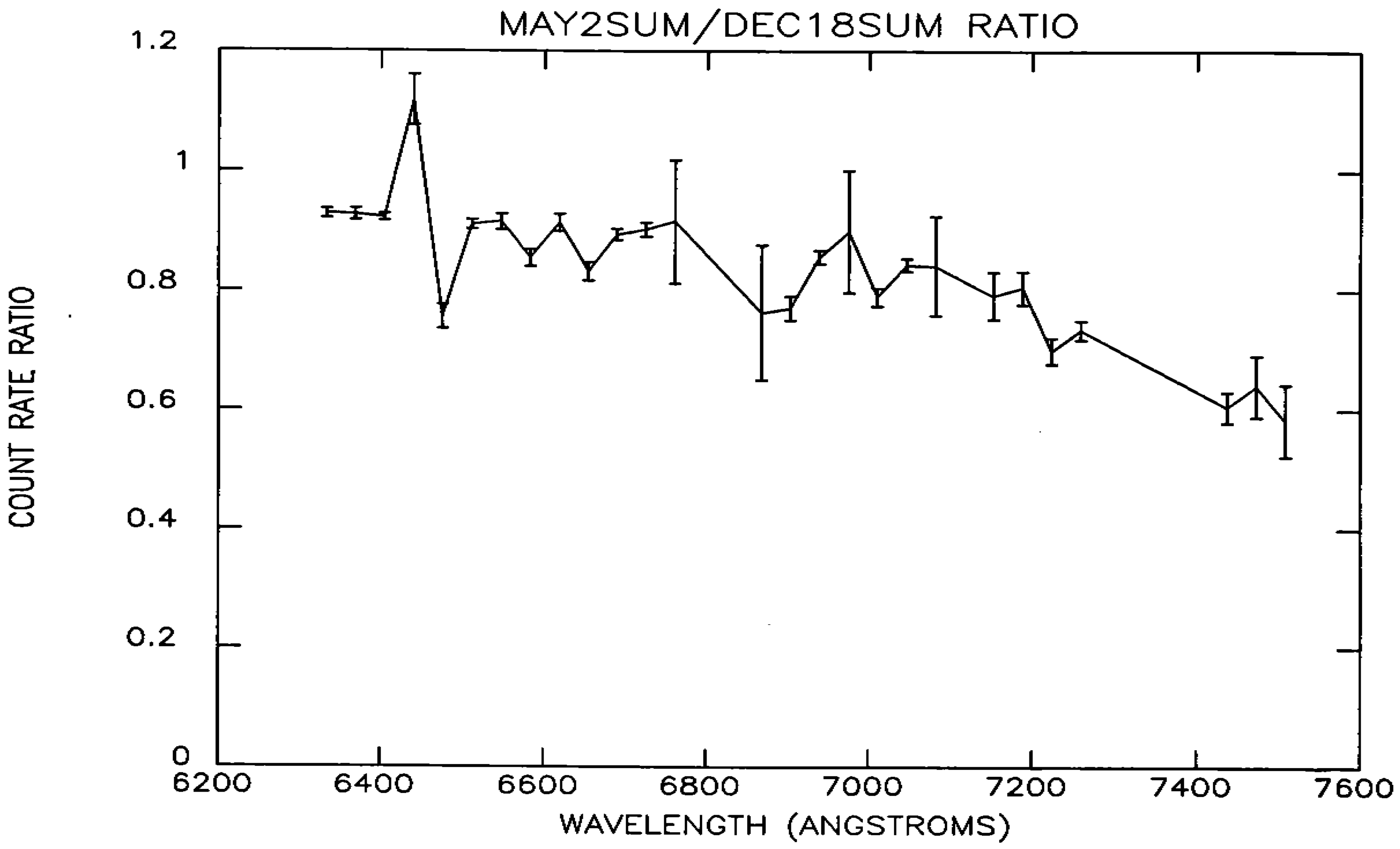
Figure 3. Same as Figure 1., but for the 12 June 1986 data, obtained during the cold balance portion of TV. Only ~ 1.1 hrs. of operation time elapsed since the 7 June measurement. No significant change from the 7 June result is apparent.

Figure 4. Same as Figure 1., but for the 24 June 1986 data, obtained during the hot balance portion of TV. Only ~ 1.1 hrs. of operation time elapsed since the 12 June measurement. No significant change from the 12 June result is apparent.

Figure 5. Same as Figure 1., but for the 20 August 1986 data, obtained in ambient conditions about 7 weeks after the termination of TV testing. The red sensitivity again shows a wavelength-dependent decay.

Figure 6. The 20 August 1986 data compared to the spectra of 2 May. The red response of F8 has apparently degraded to nearly the pre-TV levels, but at a faster rate than the December-May decay.

Figure 7. Comparison of G780H spectra of the internal, cross-strapped calibration lamp with the F3 detector during and after thermal-vacuum testing at MMDA in July 1984. The red response of F3 was known to be very stable during this period. A wavelength-independent increase of ~ 20% in lamp output, when operated at cold TV temperatures, is indicated.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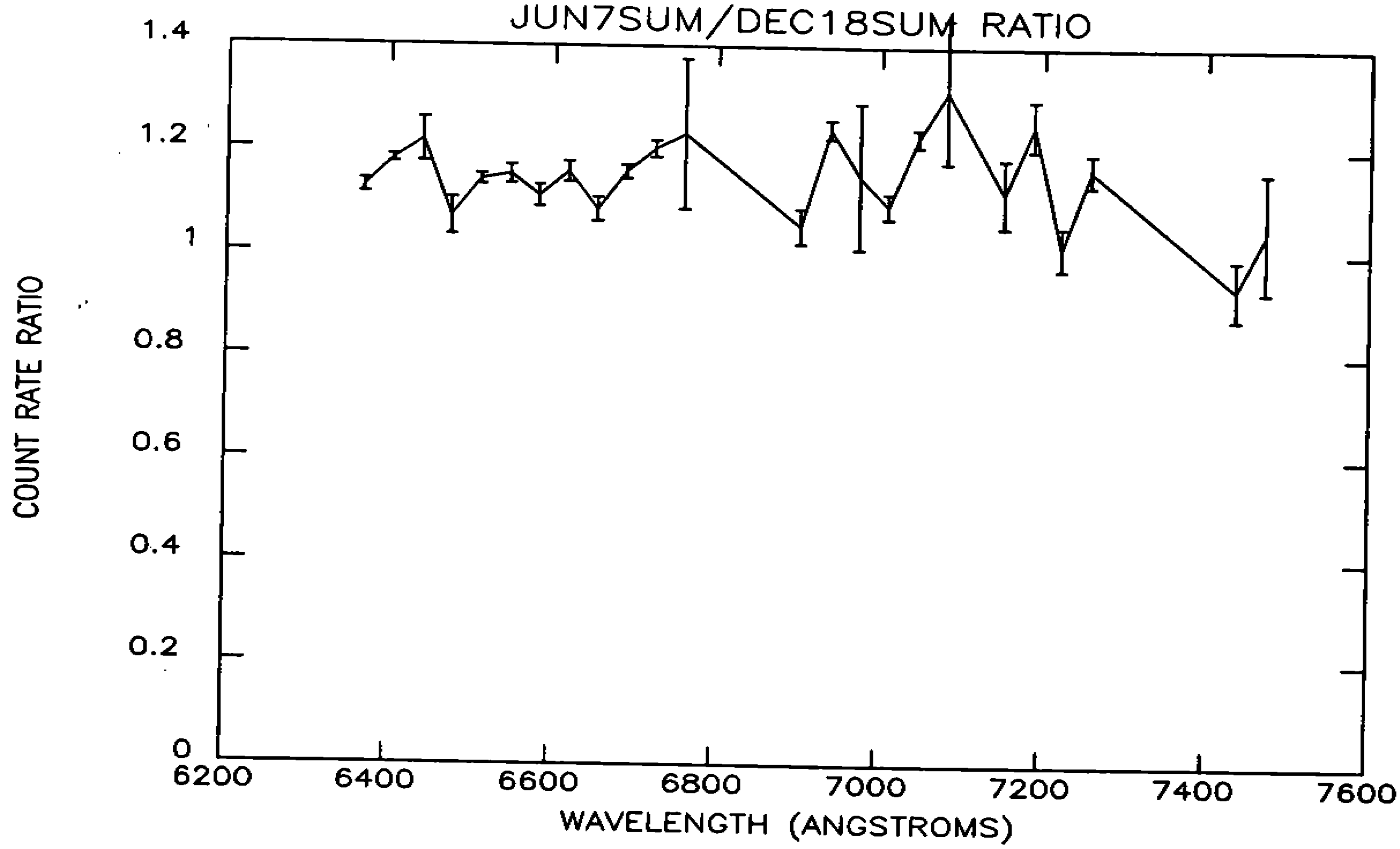
WAVELENGTH (ANGSTROMS)

Figure 1.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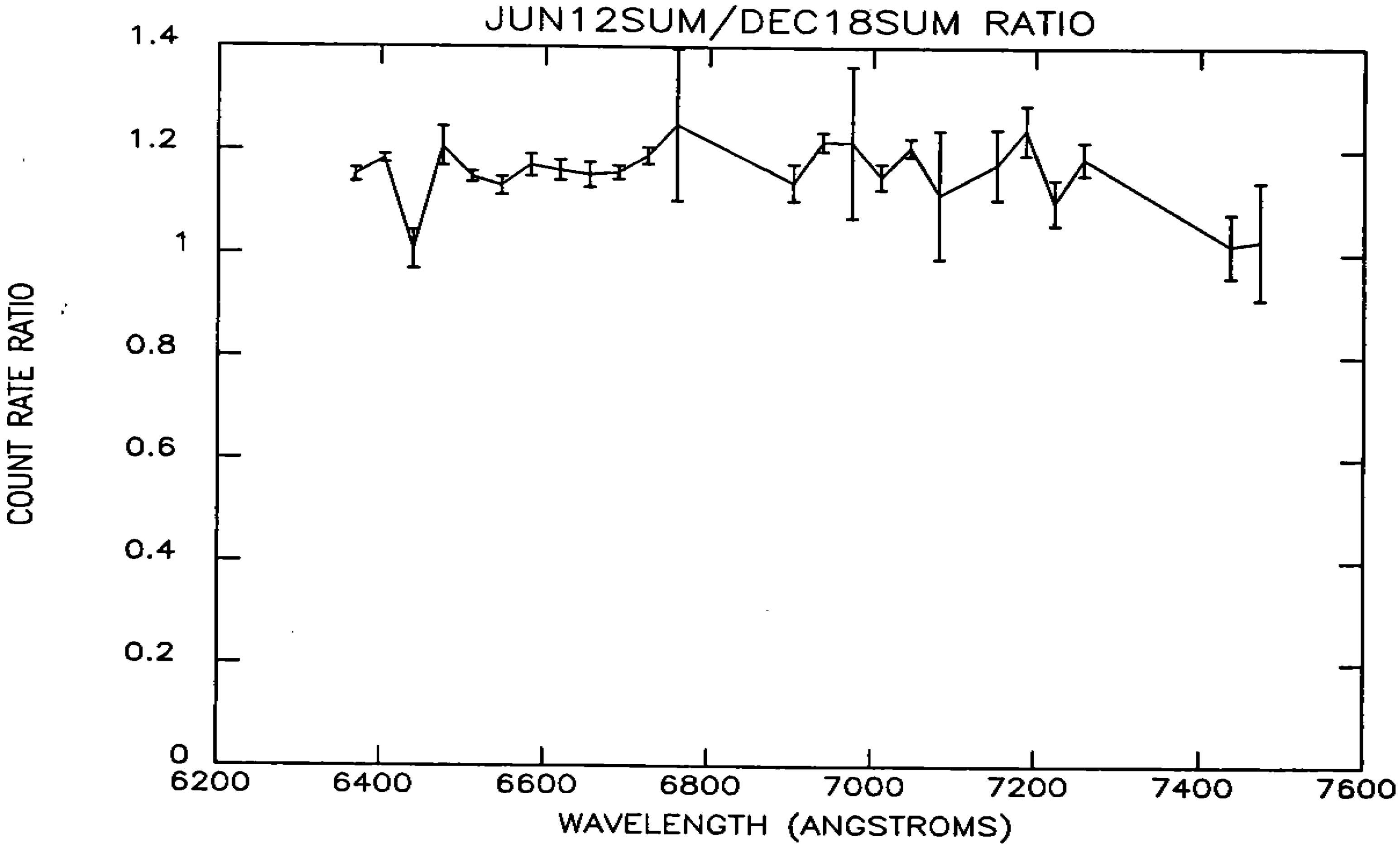
WAVELENGTH (ANGSTROMS)

Figure 2.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WAVELENGTH (ANGSTROMS)

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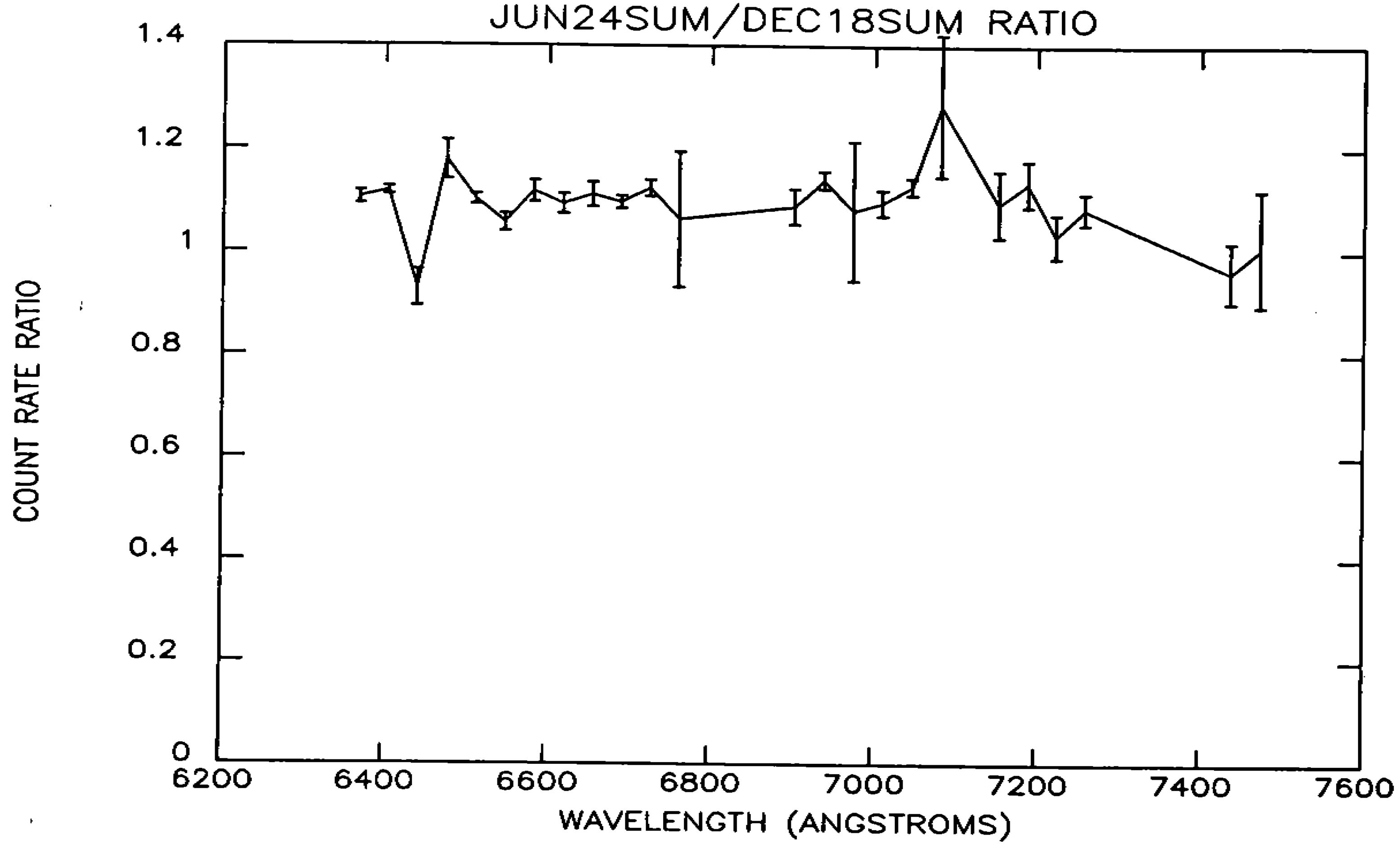
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WAVELENGTH (ANGSTROMS)

Figure 4.

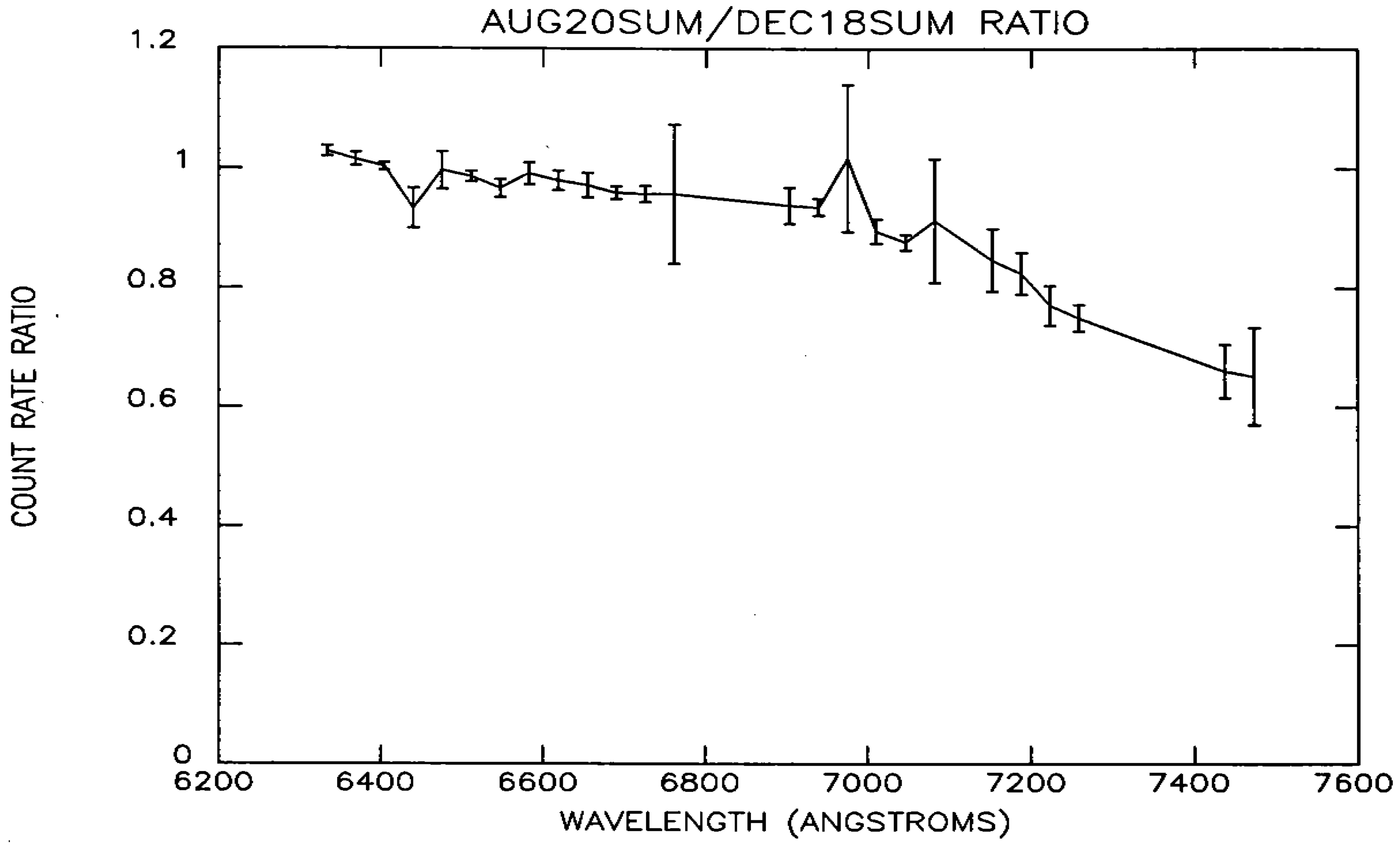
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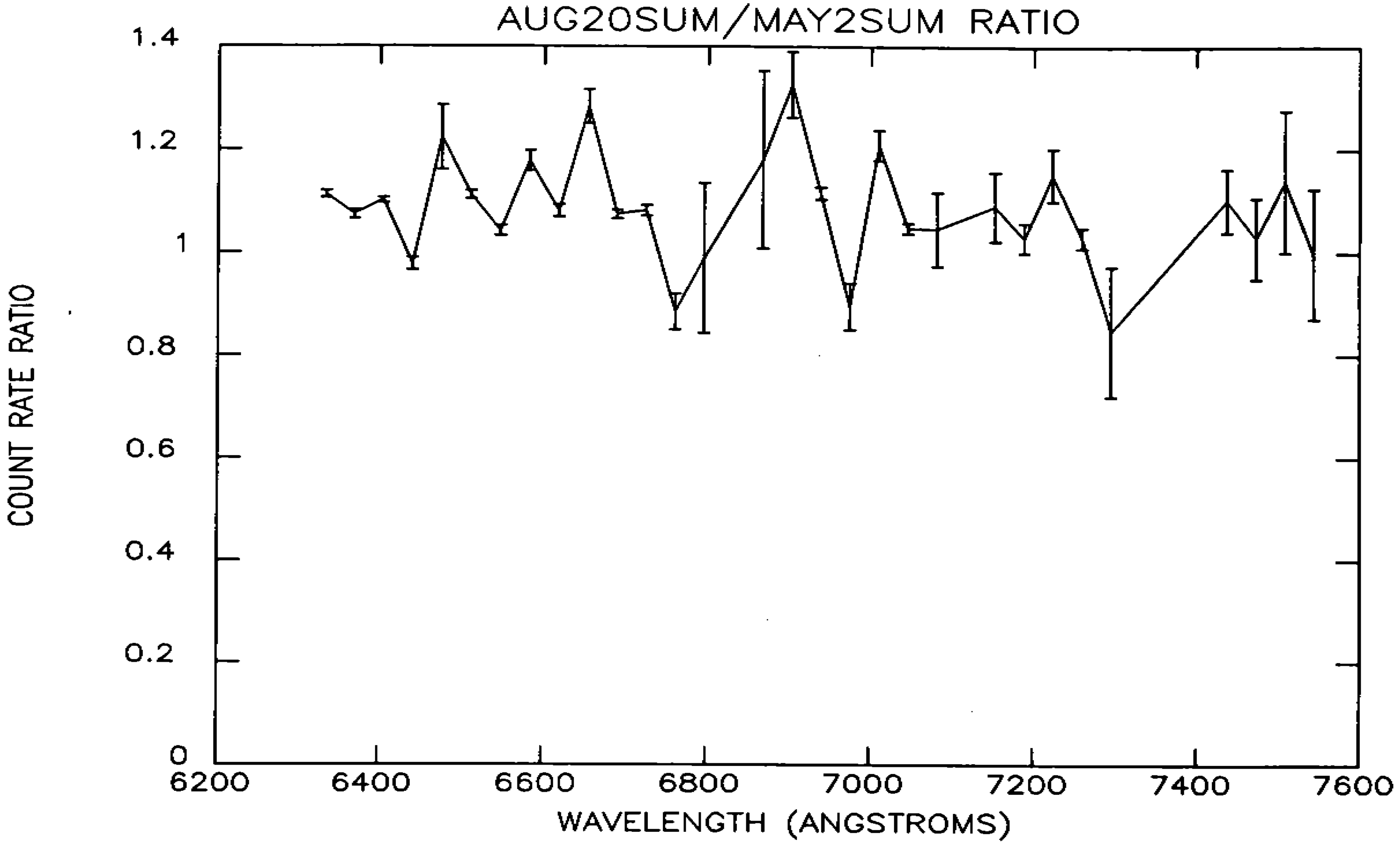
Figure 5.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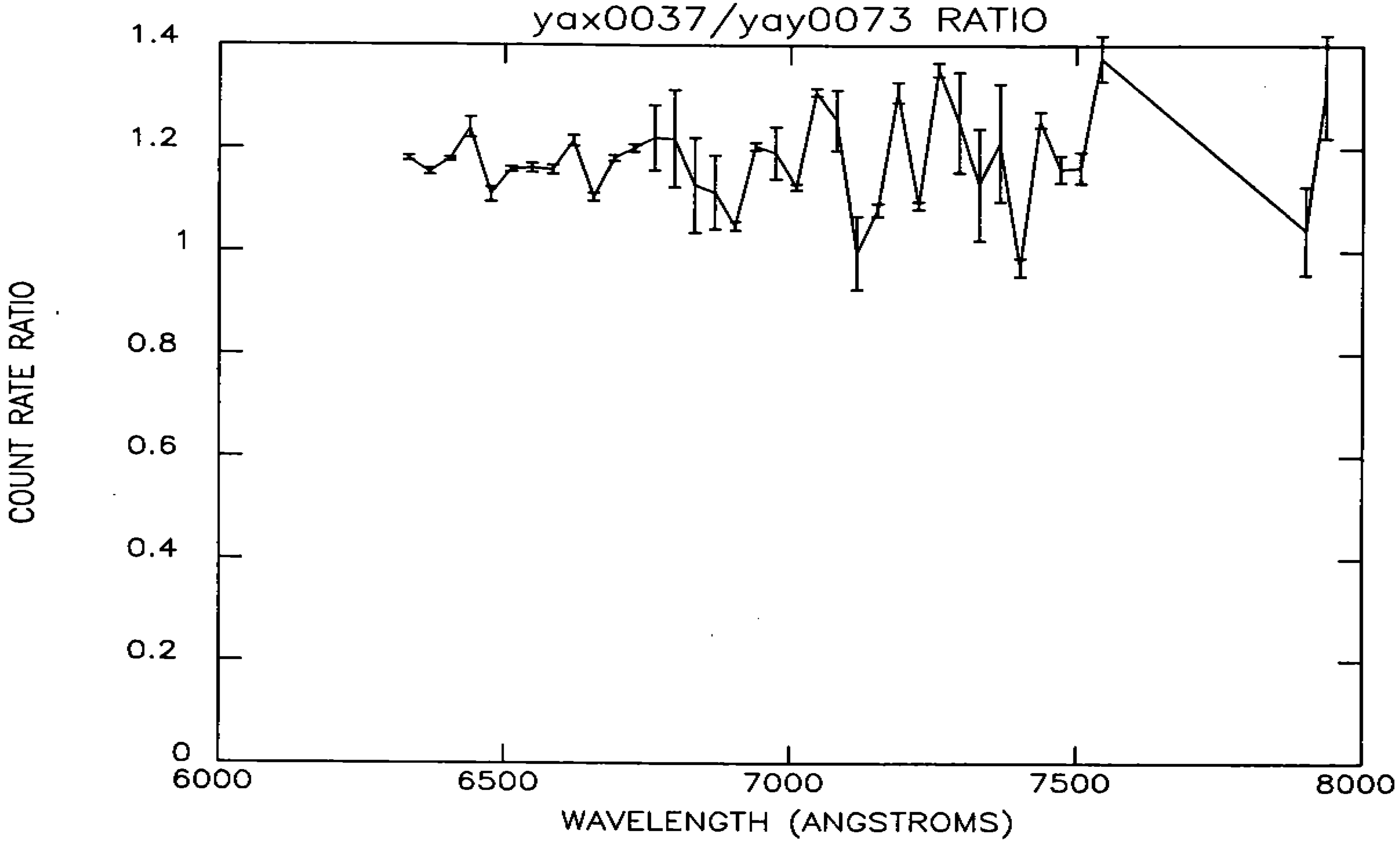
WAVELENGTH (ANGSTROMS)

Figure 6.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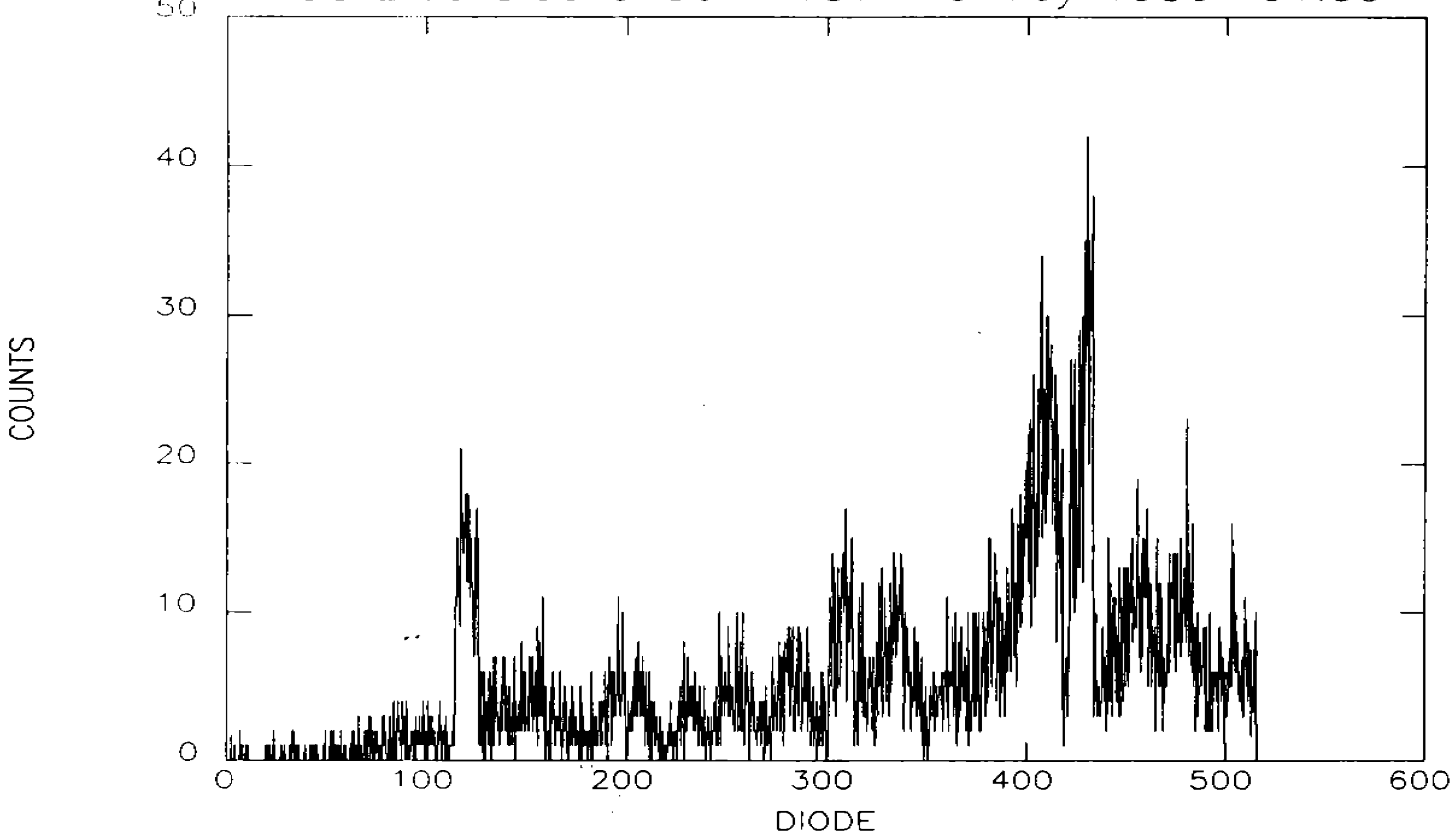
WAVELENGTH (ANGSTROMS)

Figure 7.



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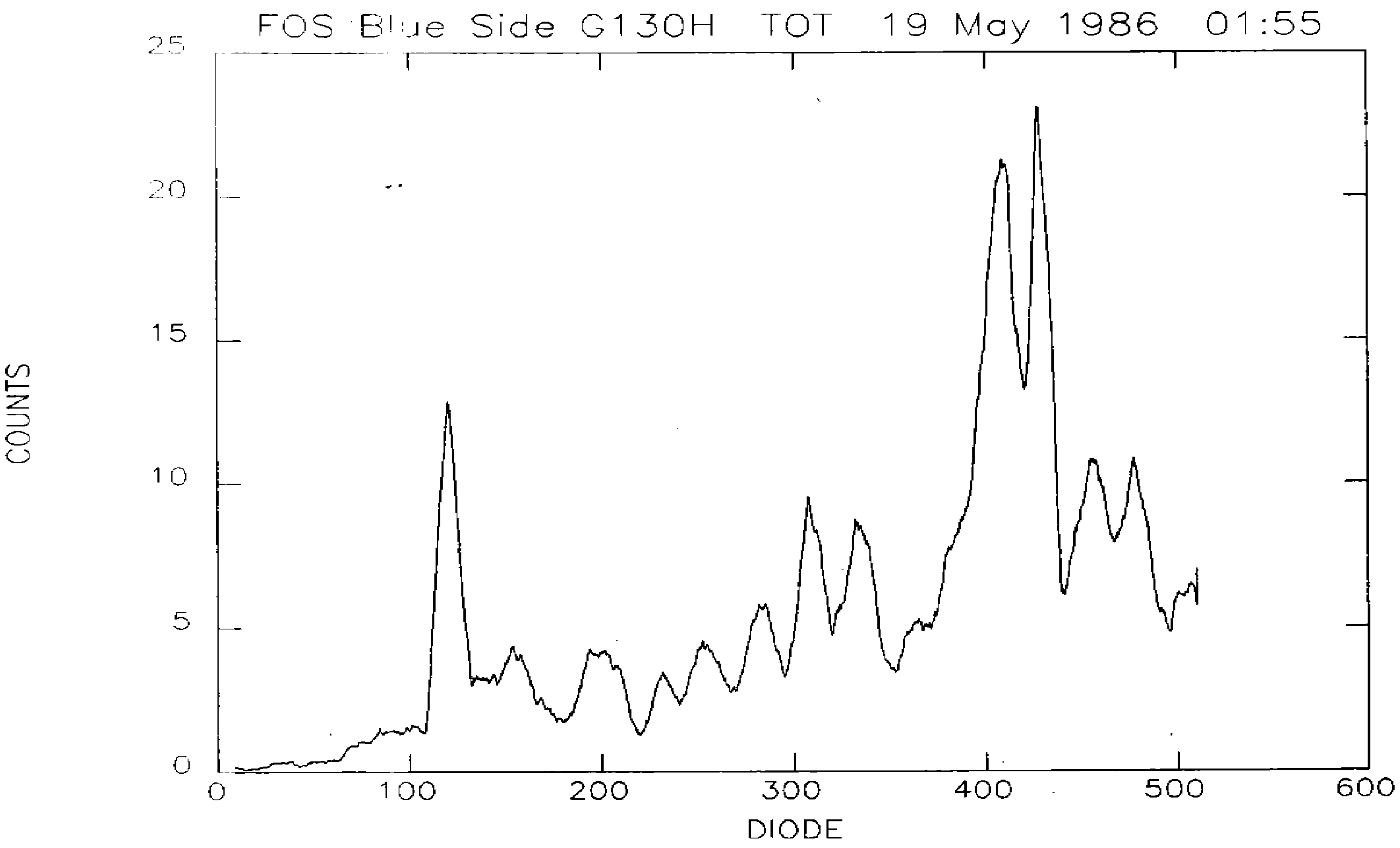
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