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Removal of Straylight in FOS Observations

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Introduction

The FOS suffers from a straylight problem that is especially apparent in observations of late-type stars taken in the 1150-2100A region. Flux calibrated observations of these objects show an artificial increase in flux in the shorter wavelengths. The problem is easily seen when comparing observations with observations from other instruments such as the HRS. Since the UV flux from late type stars is very weak, the presence of straylight from the optical part of their spectrum often completely swamps the spectral features of interest, making it very difficult to detect them over such an abnormal background. In order to provide a way to estimate the amount of straylight to be expected (so that exposure times can be adjusted to yield the appropriate signal to noise for the spectral features one wants to study), we have developed a very simple 'model' for this effect and used it to predict the amount of straylight in actual observations.

The main idea behind this method of straylight removal is that the light is not due to grating scatter. This assumption is supported by two observational evidences: that the straylight is constant (at least in first approximation) across the entire diode array when viewed as raw counts/s/A (Fig 1), and that its amount does not depend on the grating used (Fig 2), but only on the magnitude and spectral type of the observed object. The conclusion we draw from these two points is that each diode is behaving like a photometer (with a quantum efficiency curve which is the same for all diodes, i.e. the undispersed one) which 'sees' the same amount of light as all the others. In this interpretation, the pixel to pixel variations that are indeed present (but ignored in our approximation) would not be wavelength dependent, but rather variations in illumination (due perhaps to unknown geometrical effects).

Starting from this simple assumption we have been able to construct a curve of the response of each diode to the light from stars of equal magnitude and of the various spectral types. We have also produced curves for various aperture sizes and values of reddening, and used actual observations to determine the curves' zero points.(Figs 3-10)

A detailed analysis of the various backgrounds affecting FOS spectra has been made by M. Rosa. His treatment of the straylight problem is very similar to the one described here, and we refer to his paper for a more comprehensive description of the background removal from FOS spectra.

Observations of HD144858

An example of the excess flux due to straylight can be seen in figure 1a,b where the observation of 16 CYG B are compared to a reference spectrum of a G2V star. The extra flux detected by the diode array is readily apparent. Figure 1c shows the difference spectrum (i.e. the straylight). Dividing this spectrum by the inverse sensitivity function, the actual number of counts/s detected by the diode array is obtained. Figure 1d shows that the straylight is constant across the diode array. There are approximately 1046 counts/s/A of straylight detected by the instrument for a G2V star with V=0.

Predicting the Amount of Straylight

Spectra from the BPGS spectra library were used as the data to construct the graphs of the amount of straylight as a function of spectral type. The spectra were all normalized to the same V magnitude by convolving them with a Johnson V passband. Each spectrum was then multiplied by the detector's quantum efficiency and the aperture throughput for the 1.0 arcsecond round B aperture, (B-3), then summed along the entire wavelength range to get the total light detected by the undispersed FOS. Finally, the plot was scaled to actual observations (e.g. of 16 Cyg B) and renormalized for a V magnitude of 15 (Figs 3-10). Since observations of unreddened stars are not very common (so direct comparison between our curve and the data would be meaningless), we have also constructed curves for reddened spectra, using the same technique (the spectra were reddened before the normalization to the same V magnitude). Fig1 shows the various curves and the observed values of straylight from some observations. The agreement is quite satisfactory, especially since this method is more a predictive tool than a way to actually remove the straylight after the observation.

It is clear from figure 3 that blue stars produce a larger amount of straylight than late type stars. This is not surprising, given the sensitivity of the diodes to the UV and the fact that in our hypothesis they are detecting essentially a fraction the whole spectrum. However, the 'contamination' by straylight is a problem only for objects with negligible UV flux: for hot stars, the amount of straylight represents only a very small percentage of the total flux detected, and although one may want to subtract it, no obvious 'distortion' of the continuum is expected to be seen in these spectra.

Amount of Straylight in FOS Observations

To compute the estimated amount of straylight, one simply has to read the value of straylight expected for the spectral type of the object and scale it to the appropriate magnitude using the equation:

$$Straylight = 10^{-0.4(m-15)} \times Straylight_{V=15}$$

where m is the magnitude of the object, and $Straylight_{V=15}$ is the value from the graph.

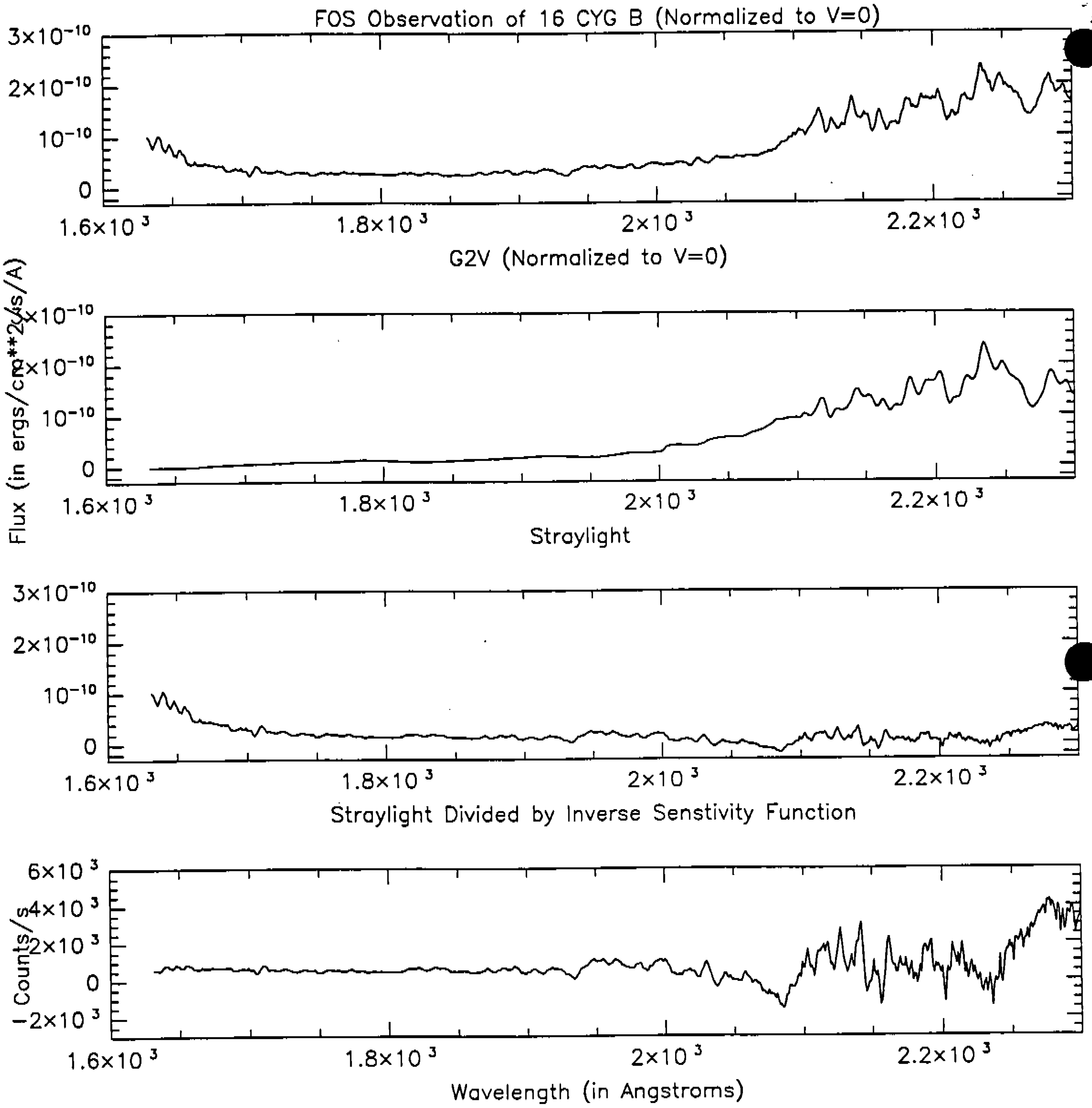
References

Baity,William,A.,ed.; "Faint Object Spectrograph Science Verification Report"; STScI; May 1992.

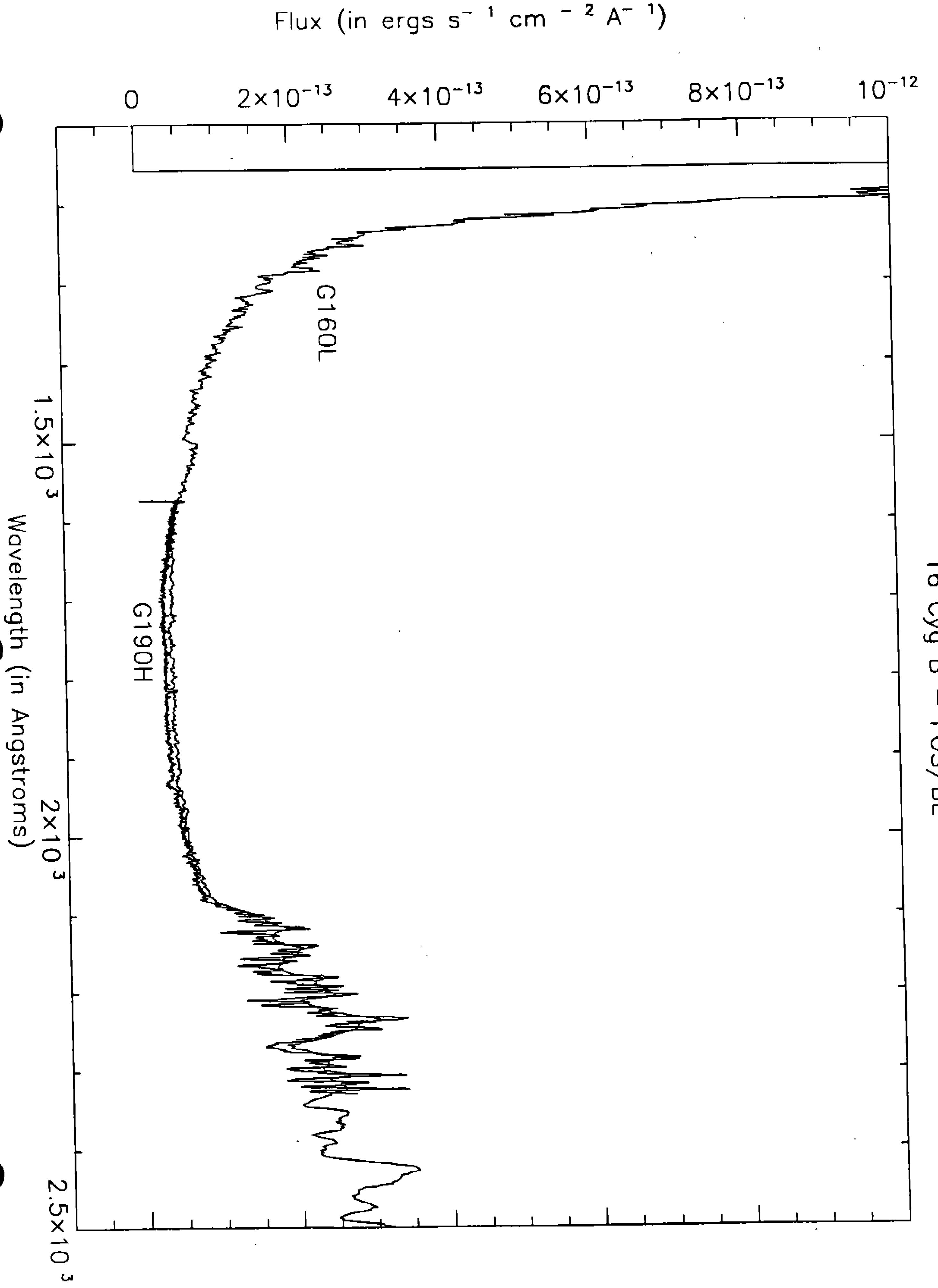
Kinney,A.L.; "Faint Object Spectrograph Instrument Handbook"; STScI; April 1992.

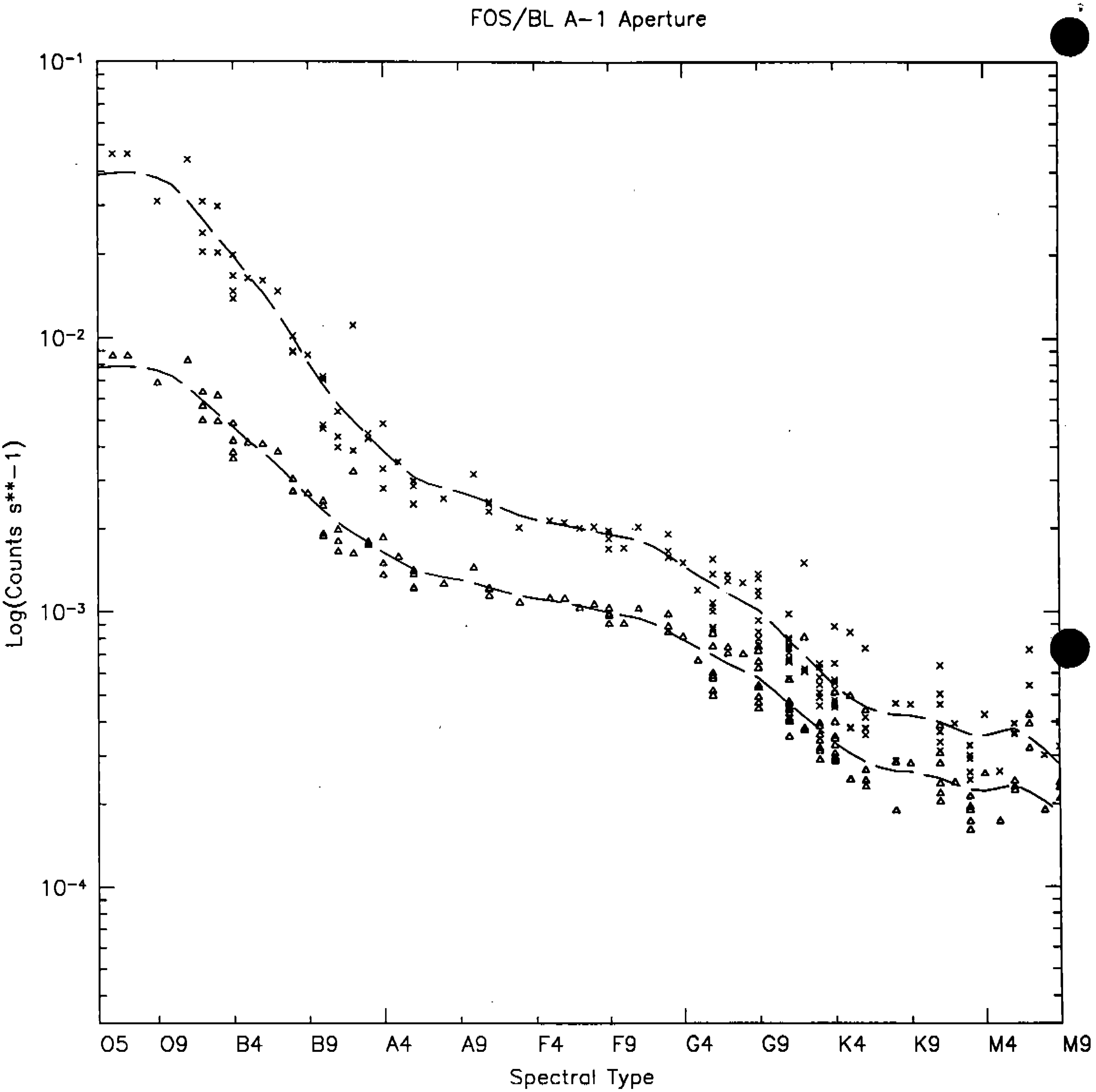
Rosa, M.; "Correcting for FOS background"; ST-ECF Newsletter; August 1993.

This research has made use of the Simbad database, operated at CDS, Strasbourg, France.

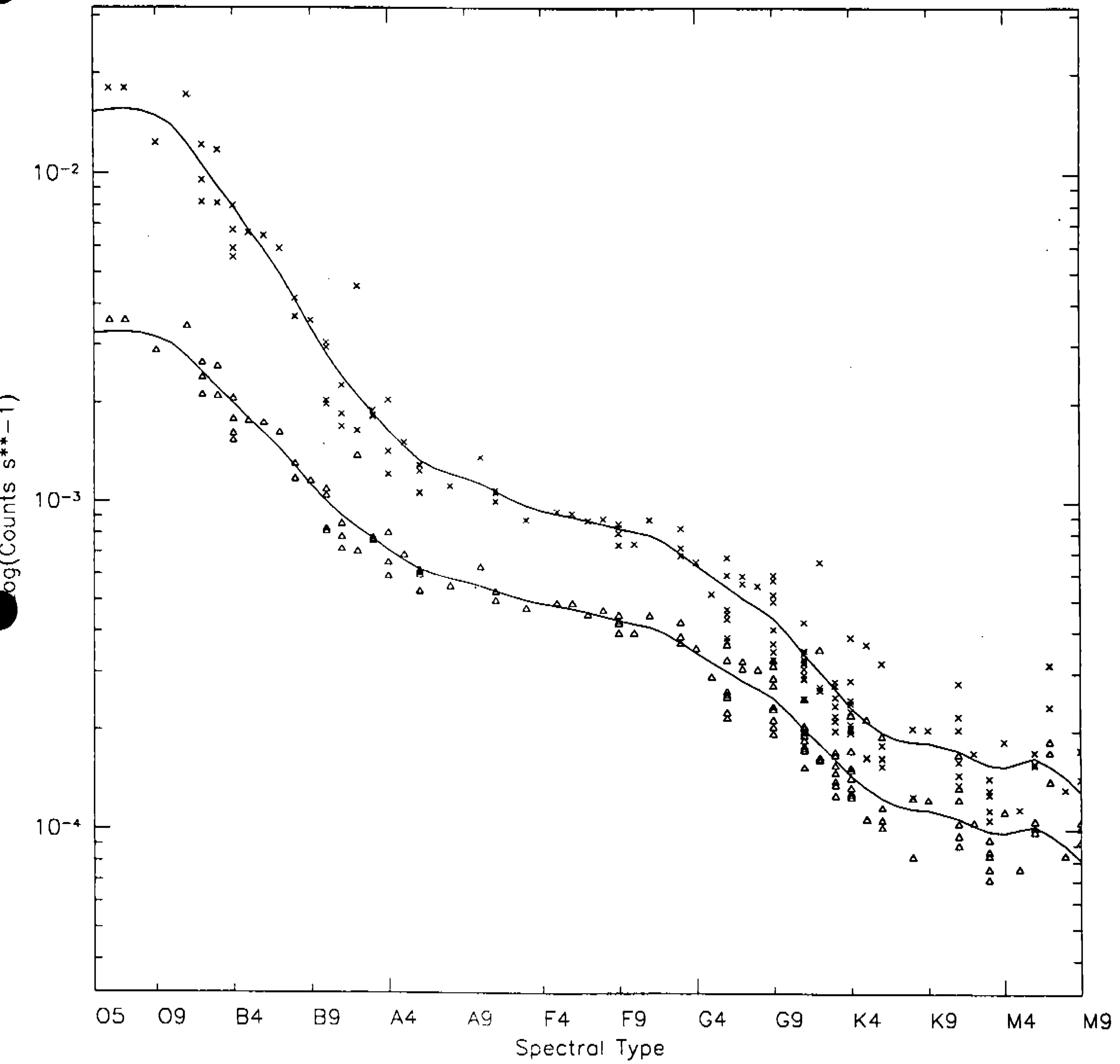


FOS Observation of 16 CYG B (Normalized to V=0)
3×10^-10
2×10^-10
10^-10
0
1.6×10^3
1.8×10^3
2×10^3
2.2×10^3
G2V (Normalized to V=0)
Flux (in ergs/cm**2/s/A)
Straylight
Straylight Divided by Inverse Senstivity Function
6×10^3
4×10^3
2×10^3
0
-2×10^3
Counts/s
Wavelength (in Angstroms)

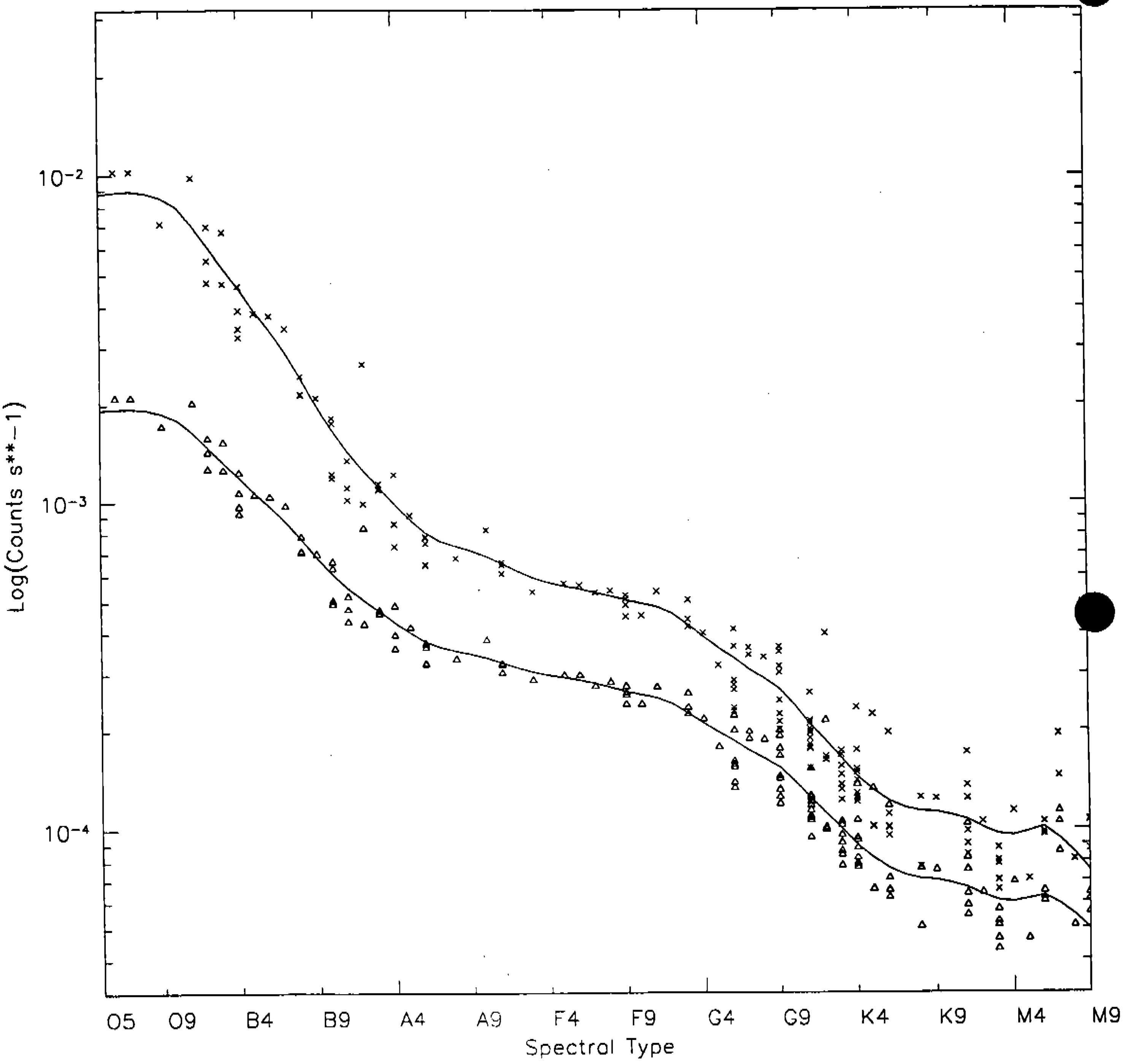

Flux (in ergs s⁻¹ cm⁻² A⁻¹)
0
2x10^-13
4x10^-13
6x10^-13
8x10^-13
10^-12
G160L
G190H
1.5x10^3
2x10^3
2.5x10^3
Wavelength (in Angstroms)

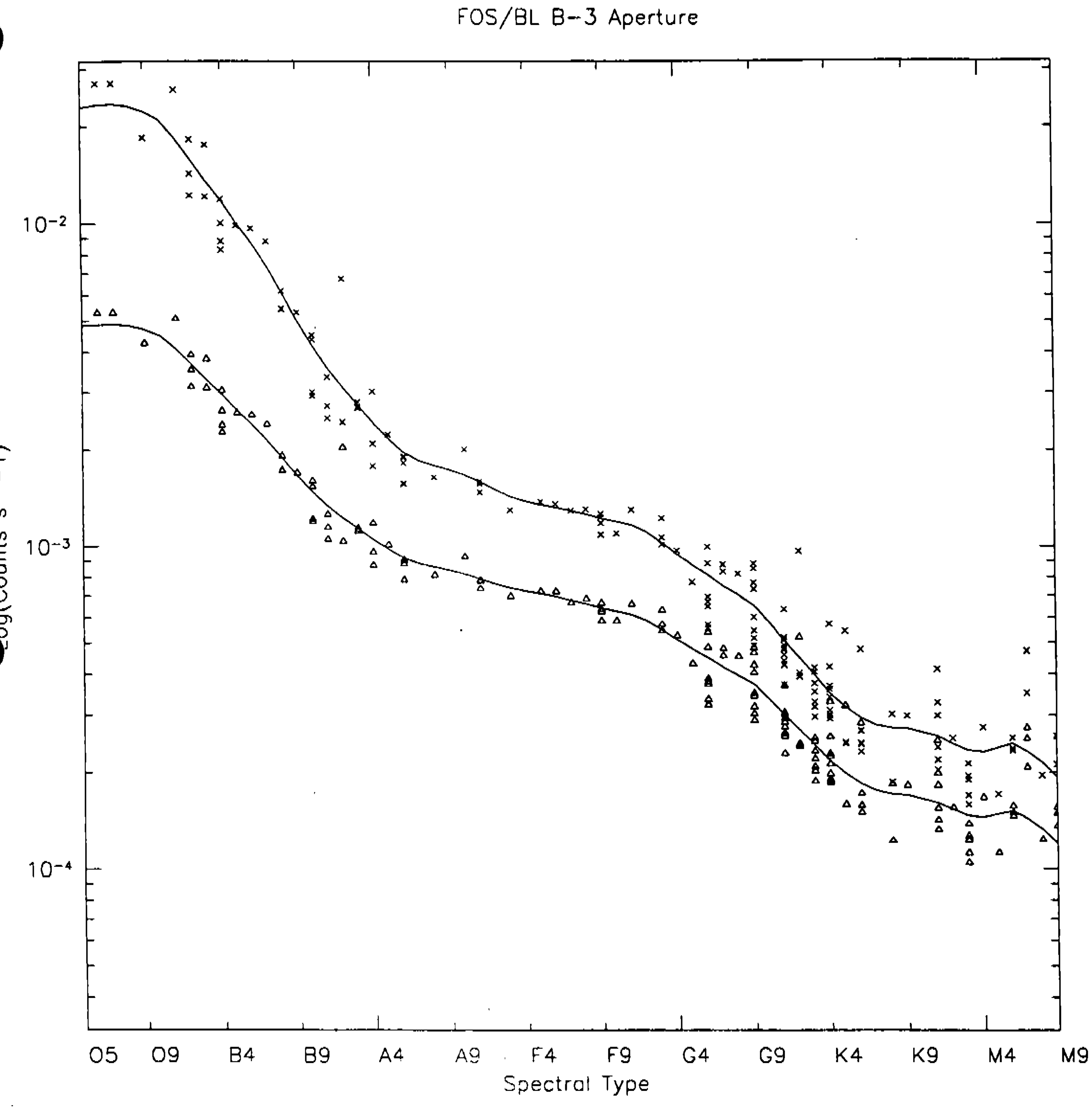

FOS/BL A-1 Aperture
10^{-1}
10^{-2}
10^{-3}
10^{-4}
Log(Counts s**-1)
O5
O9
B4
B9
A4
A9
F4
F9
G4
G9
K4
K9
M4
M9
Spectral Type

FOS/BL B-1 Aperture

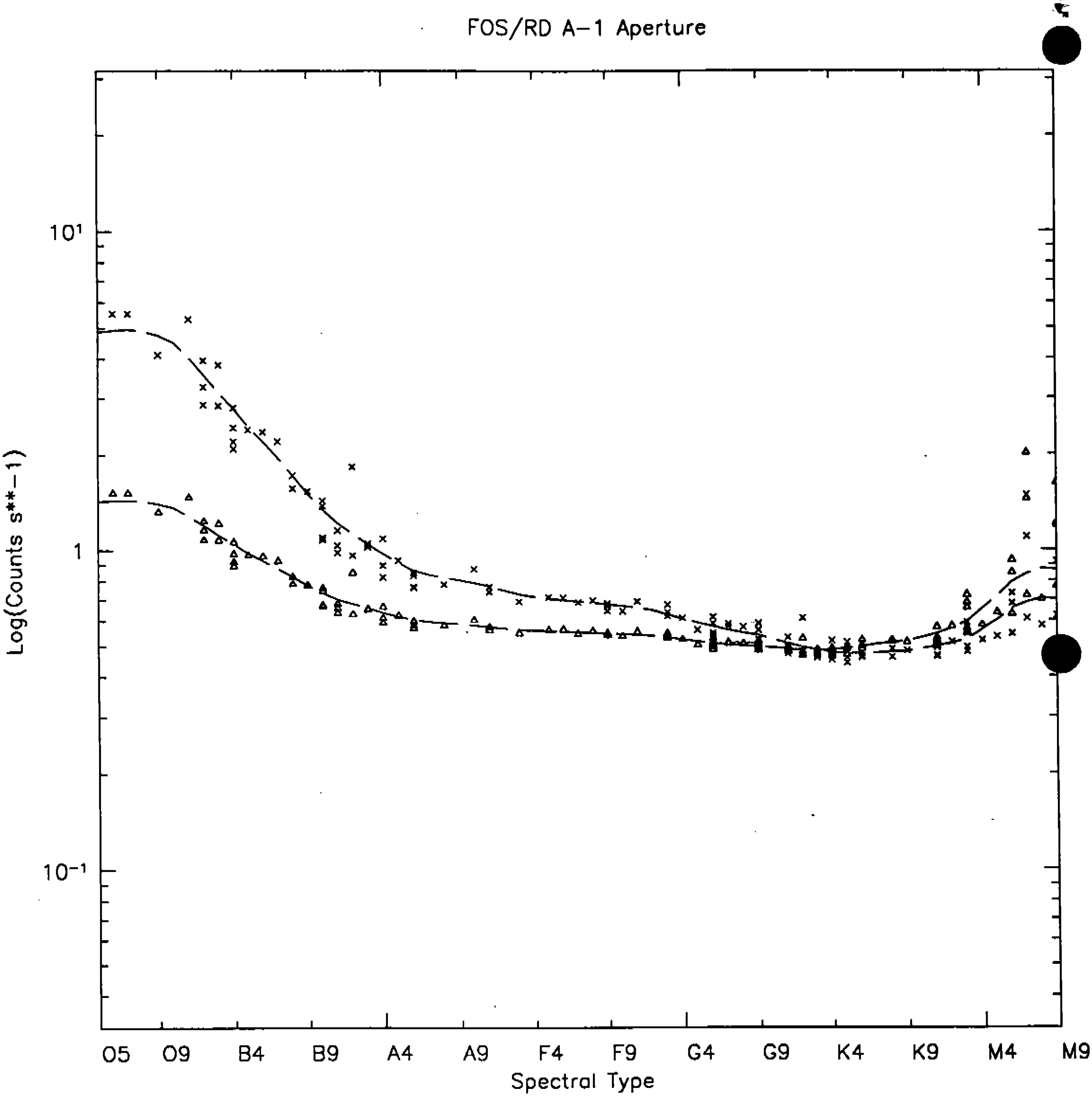


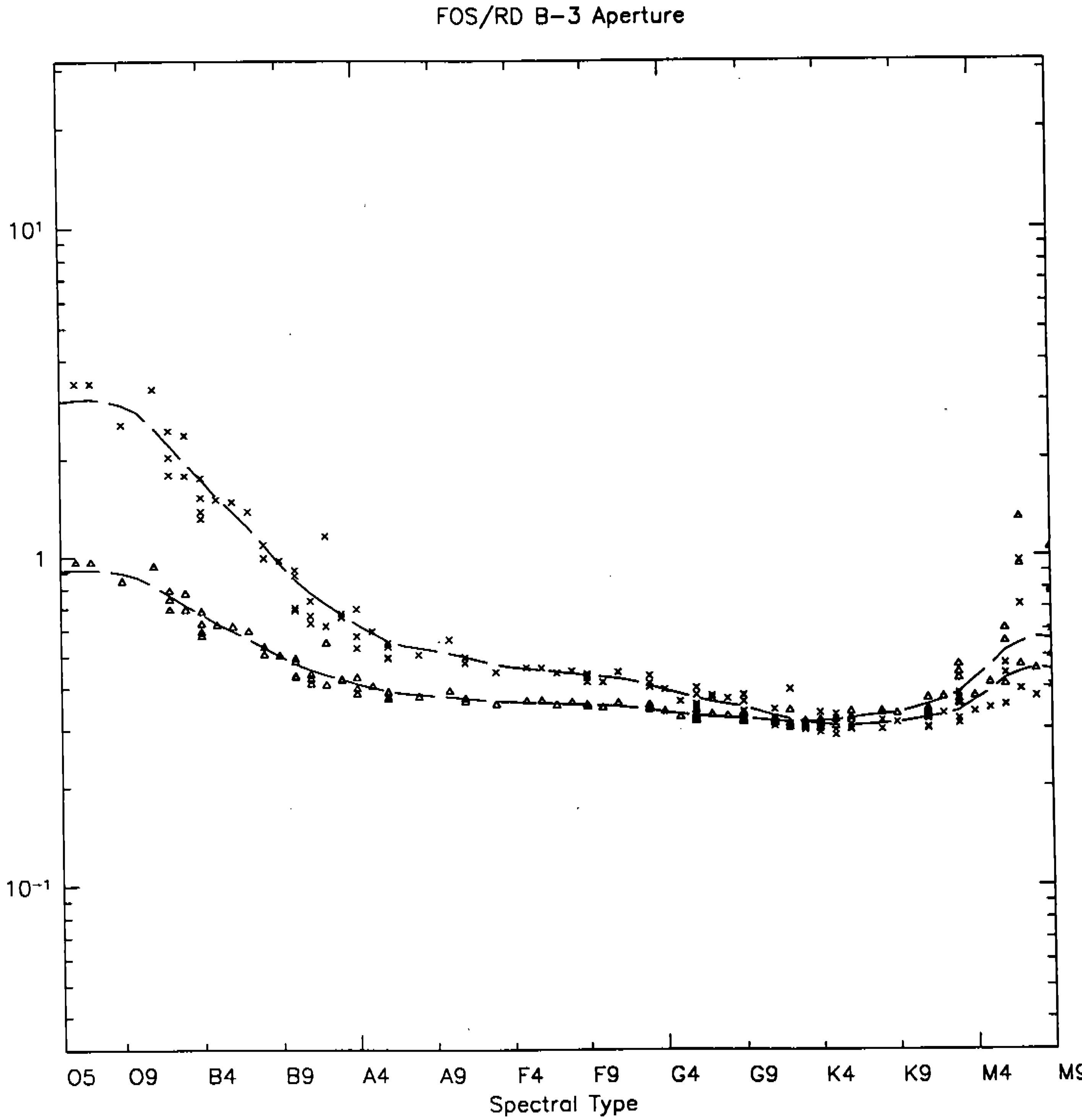
FOS/BL B-2 Aperture





FOS/BL B-3 Aperture
Log(Counts s**-1)
10⁻²
10⁻³
10⁻⁴
O5
O9
B4
B9
A4
A9
F4
F9
G4
G9
K4
K9
M4
M9
Spectral Type


FOS/RD A-1 Aperture
Log(Counts s**-1)
10^1
1
10^{-1}
O5
O9
B4
B9
A4
A9
F4
F9
G4
G9
K4
K9
M4
M9
Spectral Type


FOS/RD B-3 Aperture
10^1
1
10^{-1}
Log(Counts s**-1)
O5
O9
B4
B9
A4
A9
F4
F9
G4
G9
K4
K9
M4
M9
Spectral Type