Time-Dependent Photometric Sensitivity of FES No. 2

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ABSTRACT

With the implementation of a new FES reference point in January 1990 at GSFC and in July at VILSPA, a comparison of the three reference points is necessary to determine the degradation behavior of the FES. For six IUE standard stars (three overlap, three underlap) we find the previous reference point (-16,-208) to be consistent with the behavior last reported by Fireman and Imhoff (1989) due to both the FES degradation and the formation of a fatigue spot at the reference point. The new reference point (-144,-176) combined with data from the original reference point (300,144) and including recent data taken at all three reference points provides us with information on the FES degradation decoupled from any fatigue. These data show that the FES sensitivity has decreased by approximately 1.3% per year and is not significantly different for either overlap or underlap mode. Furthermore, the relative gain in brightness of the new reference point is 28.7% for overlap stars, and 14% for underlap stars compared with the counts at (-16,-208).

I. Introduction

On January 22, 1990, a new FES reference point[1] (-144,-176) was implemented by GSFC to replace the fatigued old reference point (-16,-208). VILSPA began using the new reference point on July 23, 1990. A comparison of these two reference points along with the original reference point (300,144) –which was abandoned on August 1, 1979, because the slews to the apertures went directly across the low reflectivity patch– provides information on the nature of the FES sensitivity and any degradation behavior. This, in turn, may eventually lead to an improved calibration for the FES No.2.

Previous calibration attempts have been published over the years. These include Holm and Crabb (1979), Stickland (1980), Holm and Rice (1981), Barylak (1984), Barylak et al. (1985), Wasatonic (1985), Barylak and Gry (1986), Imhoff and Wasatonic (1986), Imhoff et al. (1986, 1987, 1988), and Fireman and Imhoff (1989). Recently, Barylak (1990) and Fireman and Imhoff (1990) have shown that the FES sensitivity measured at the previous reference point (-16,-208) appears to level off after 1988. Furthermore, Barilak (1990) has proposed a third degree polynomial fit to model the overall sensitivity changes at this reference point.

Current operations at GSFC still use a version of the Holm and Crabb (1979) calibration, to provide an approximate magnitude for identification purposes, namely,

$$m_V = -2.5 * log[\frac{CTS}{1 - 1.87x10^{-5} * CTS}] + K, \quad (1)$$

[1] A reference point is a common spot on the FES where all targets are placed before being slewed into the apertures.

where CTS are the observed FES counts, K = 16.58 for overlap stars and K = 11.05 for underlap stars.

We warn that equation (1) does not include a sensitivity degradation correction being only good to within a few tenths of a magnitude. We discuss an approximate method to calibrate the counts at the new reference point, via previous calibrations, in the following section.

II. Data

FES counts from six IUE standard stars - three overlap, three underlap - were taken from past observing scripts noting which reference point was used. These data are shown in Figures 1-6 with the diamonds representing (300,144), the crosses (-16,-208), and the stars (-144,-176). We warn that this comparison of sensitivities is only limited to three positions within the FES, however we suggest that a similar loss of sensitivity is present throughout the FES. The solid line represents a fit to the (-16,-208) data that is consistent with that of Fireman and Imhoff (1989) using their published "cutoff" dates of 1981.65 for overlap and 1980.60 for underlap stars where the data began to degrade linearly. It is interesting to note that in Figures 1–6 the linear fit for data points taken after 1988 appears to deviate significantly. The dashed line represents a fit to the (300,144), (-144,-176), and pre-cutoff (-16,-208) data. The post-cutoff (-16,-208) data are more steeply decreasing due not only to an overall decrease in FES sensitivity but also due to the development of a "fatigue spot" at the reference point due to frequent saturation. The dashed line, however, represents the overall estimate of the FES degradation rate decoupled from any fatigue. This effect can be verified by examining data that were taken at (300,144) in 1984, 1989, and 1990 (see the location of the diamonds in Figures 1–6).

The diamonds during 1984 appear in general under the degradation line mainly indicating uncertainties in the measurements rather than drastic changes in the sensitivity. Significant scatter in the measurements have been found due to rapid changes in parameters such as the telescope focus (Pérez 1990). Nevertheless, most of these data show themselves to be consistent with a degradation effect decoupled from fatigue, under the assumption that the overall sensitivity of the FES had a similar zero point and it has also been changing at similar rates. The rate of degradation is very similar for all six stars and does not appear to vary between overlap and underlap modes. More information on these lines is found in Table 1. From the data presented in Table 1, we derive that on the average the new reference point at (-144,-176) is 28.7% more efficient for overlap stars and 14% for underlap stars compared with the previous reference point. We suggest that an approximate method to convert FES counts to magnitudes, via the previous reference point, would be to 'degrade' the counts in the percentages indicated above and use the time correction and other calibration equations in Fireman and Imhoff (1989) for the observing epoch.

III. Discussion

Use of the FES for photometry must be done cautiously because of the various effects on the FES. We have shown that the FES has two forms of degradation - one due to time and the other due to fatigue at one spot. In addition to these factors, for a given position in the FES such as the reference point, there are effects due to color (Wasatonic 1985), radiation (Imhoff et al. 1986), and focus (Huber et al. 1989). This last effect has become more noticeable with the increasing power constraints on IUE as the spacecraft ages.

TABLE 1

Linear Parameters[2] for Figures 1-6

Star	Mean	Slope	Y-Int.	R	σ
		Post-Cutoff (-16,-208) Lines			
HD 60753	7667.0	-0.0354	71.116	-0.922	$1.7x10^{-6}$
HD 93521	6097.8	-0.0374	75.157	-0.903	$3.9x10^{-6}$
BD +33° 2642	188.9	-0.0402	80.641	-0.924	$2.0x10^{-4}$
ζ Cas	1043.5	-0.0280	56.378	-0.879	$2.4x10^{-5}$
λ Lep	623.7	-0.0285	57.377	-0.858	$4.6x10^{-5}$
τ Sco	2412.4	-0.0264	53.231	-0.885	$1.4x10^{-5}$
		(300,144), (-144,-176), Pre-Cutoff (-16,-208) Lines			
HD 60753	7667.0	-0.0123	25.281	-0.888	$1.6x10^{-6}$
HD 93521	6097.8	-0.0132	27.177	-0.836	$3.1x10^{-6}$
BD +33° 2642	188.9	-0.0123	25.348	-0.686	$1.3x10^{-4}$
ζ Cas	1043.5	-0.0141	28.990	-0.959	$3.4x10^{-5}$
λ Lep	623.7	-0.0122	25.085	-0.980	$5.8x10^{-5}$
τ Sco	2412.4	-0.0140	28.680	-0.810	$1.6x10^{-5}$

Attempts to use the FES as a photometer should only be done very carefully. For more accurate FES photometric measurements it is always advisable to opt for differential photometry by using one or several nearby comparison stars of known magnitudes (Guinan 1990). Additional attempts to study microvariability through processing direct FES telemetry will be hampered by the effects discussed above and by the biased telemetry values due to the data sampling technique, shortcomings discussed in Pike et al. (1988) and Pepoy et al. (1989).

IV. References

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[2] Note that the slope, y-intercept, and σ, have been normalized to the mean values given which are computed from (300,144) values prior to switching to (-16,-208). This gives units of percentage decrease per year for the slope. The form of the independent variable is T=years. These numbers agree with those of Fireman and Imhoff (1989). R is the correlation coefficient.

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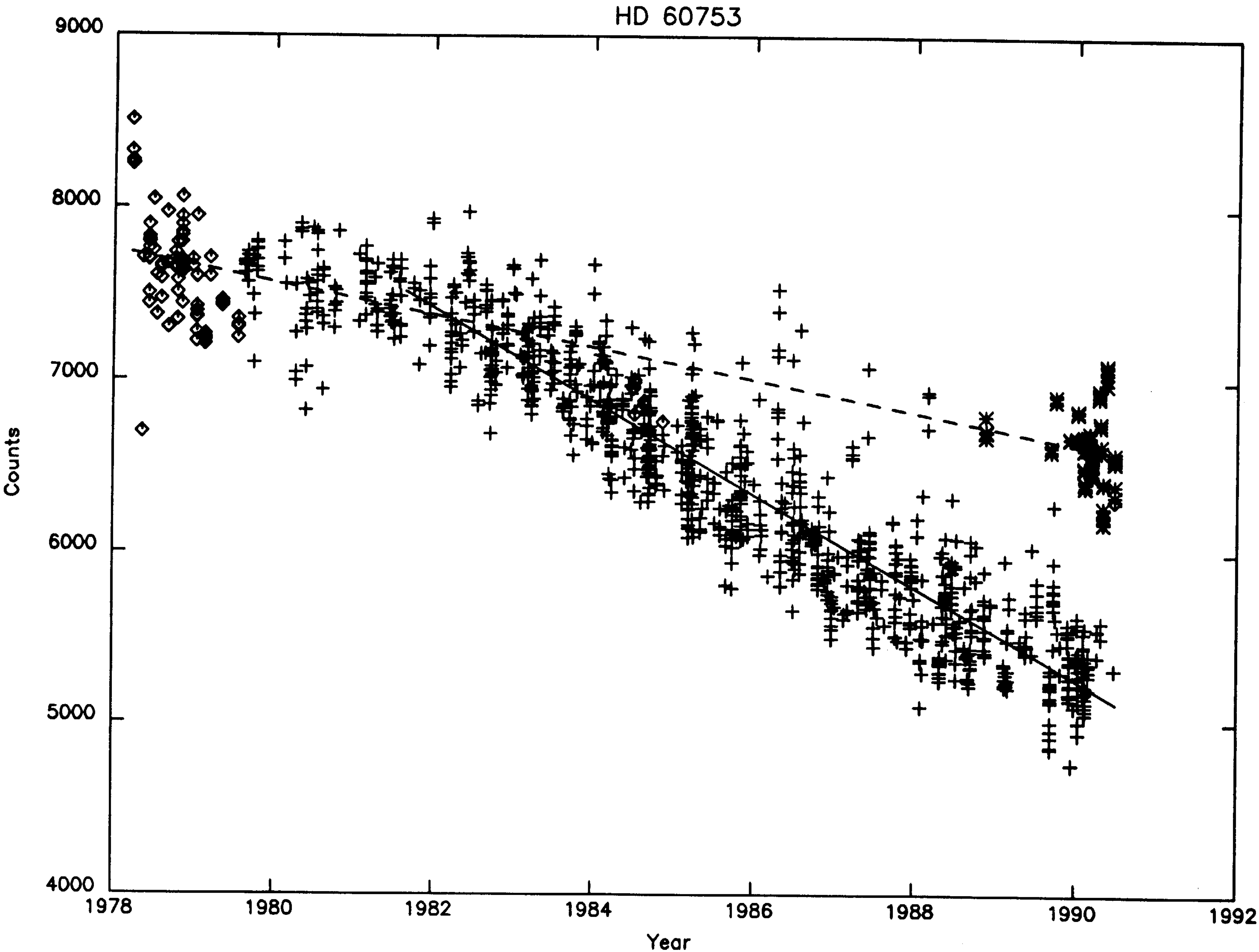

HD 60753
9000
8000
7000
6000
5000
4000
Counts
1978
1980
1982
1984
1986
1988
1990
1992
Year

Figure 1

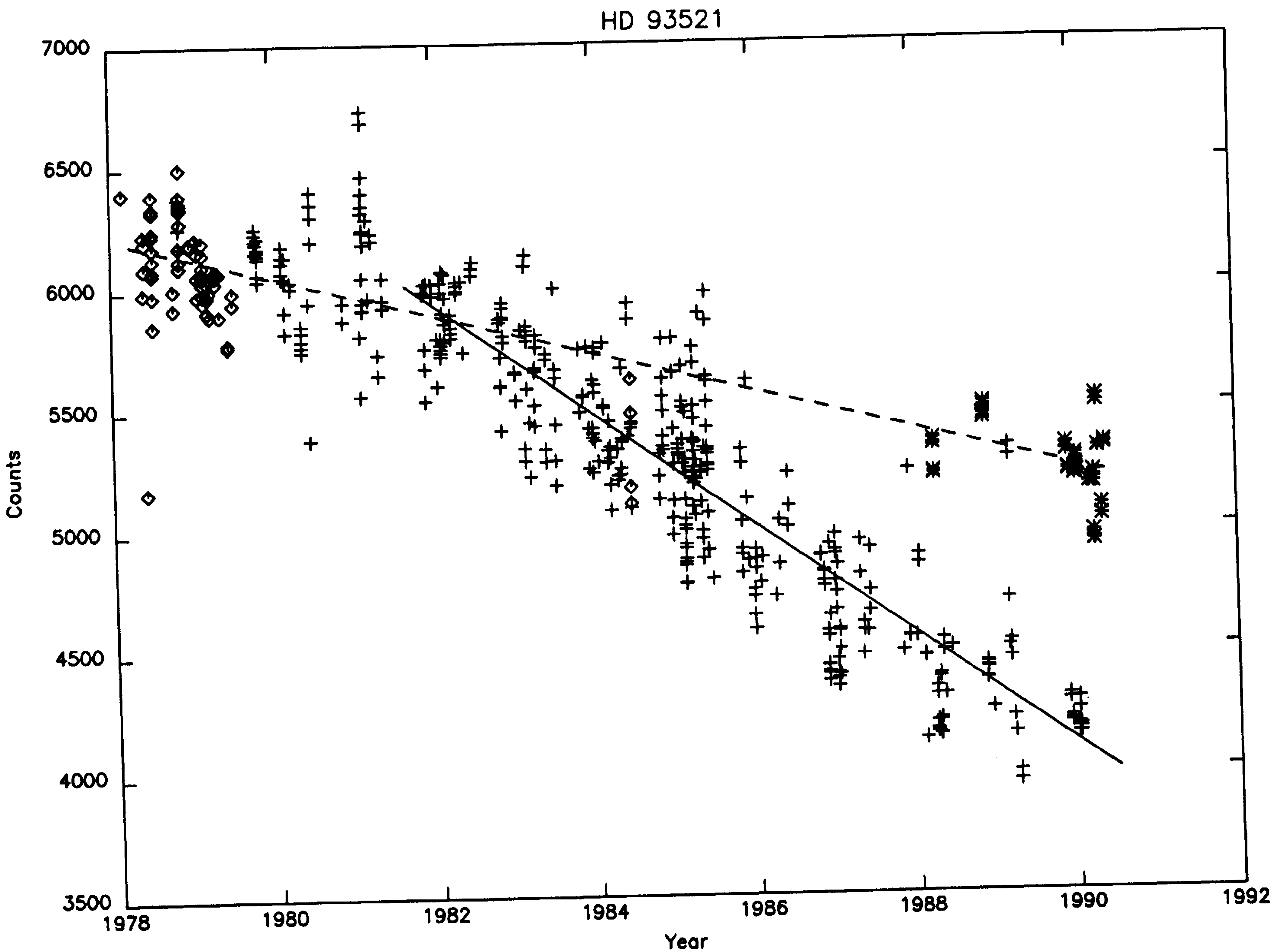

HD 93521
Counts
Year
7000
6500
6000
5500
5000
4500
4000
3500
1978
1980
1982
1984
1986
1988
1990
1992

Figure 2

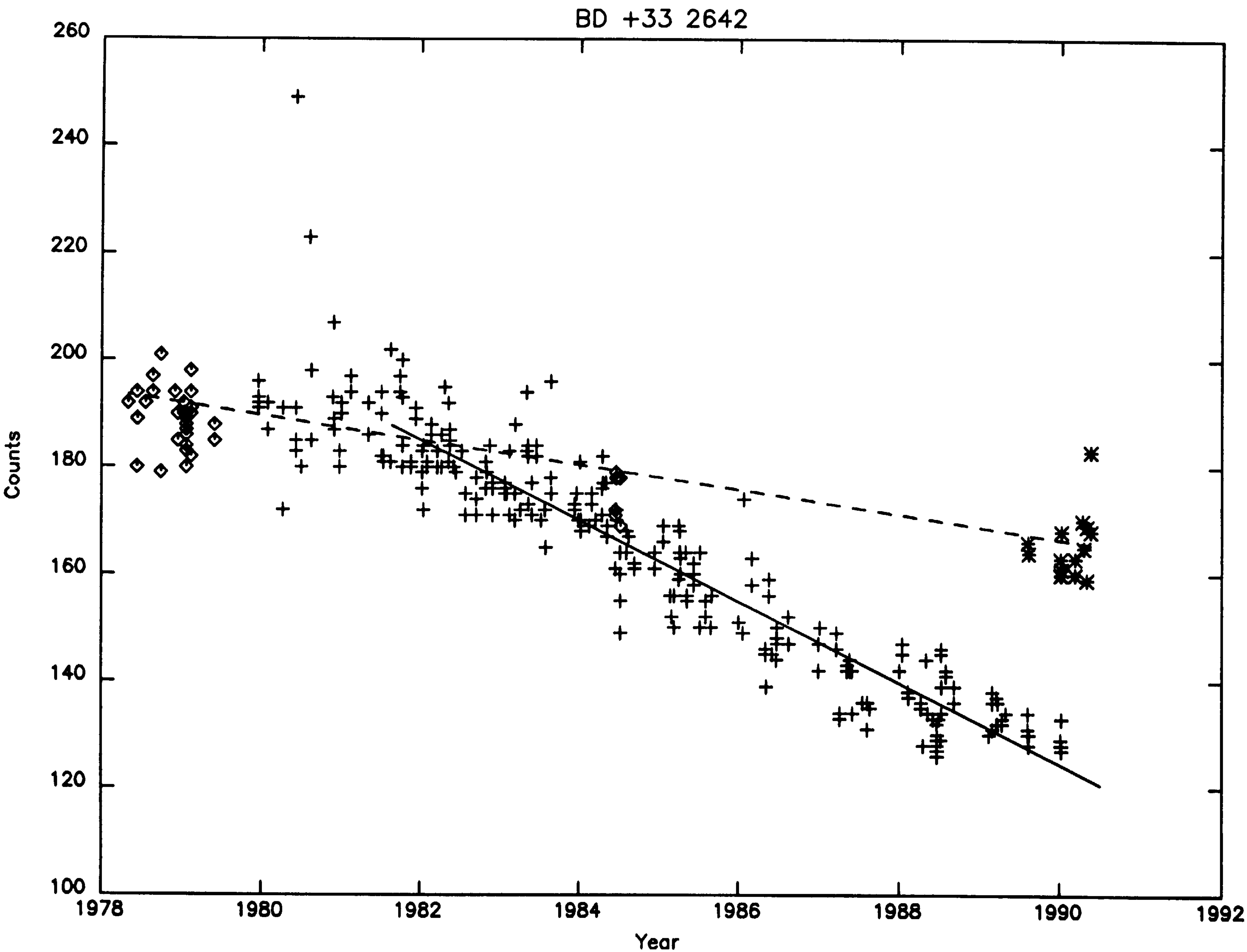
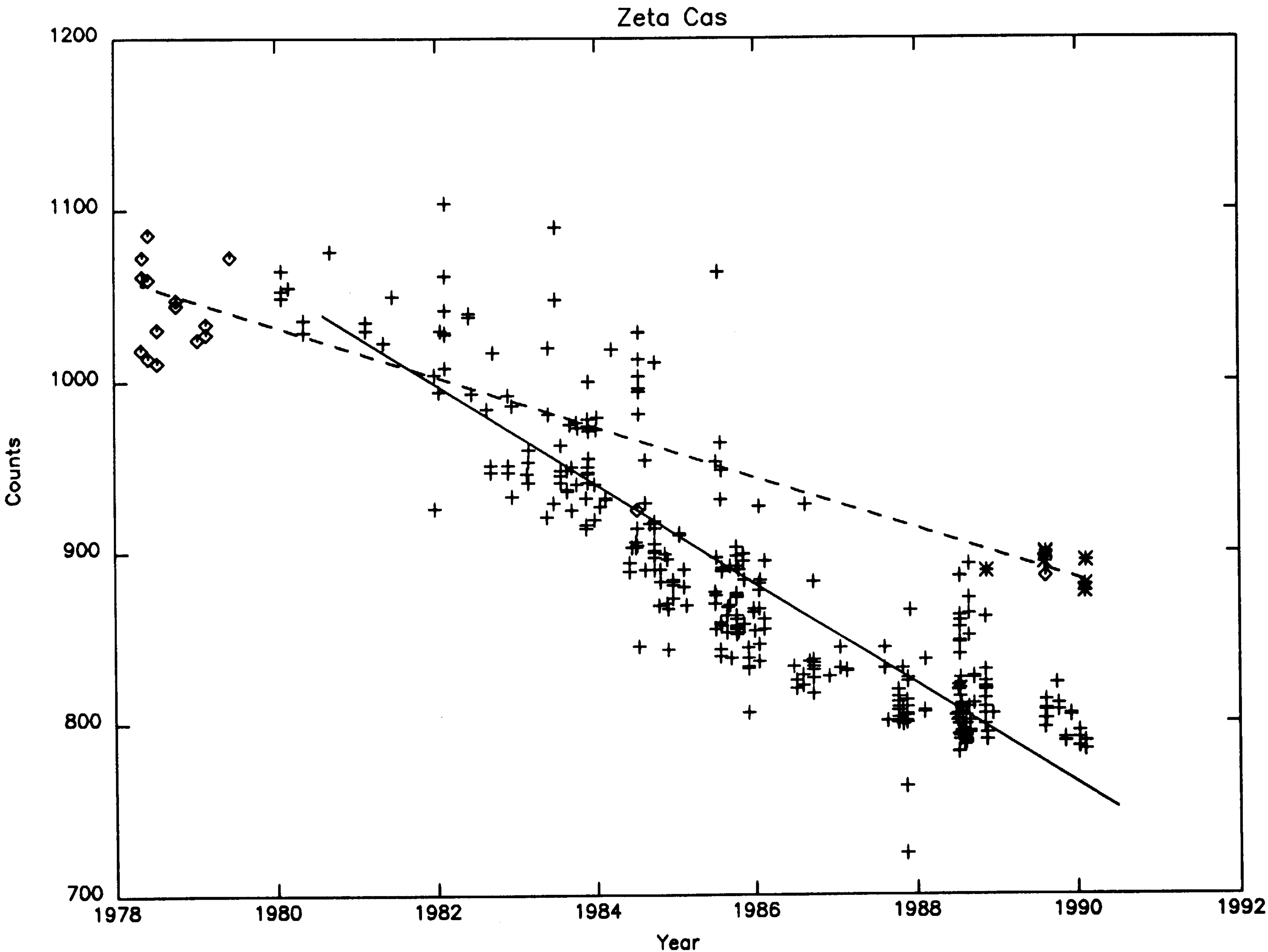
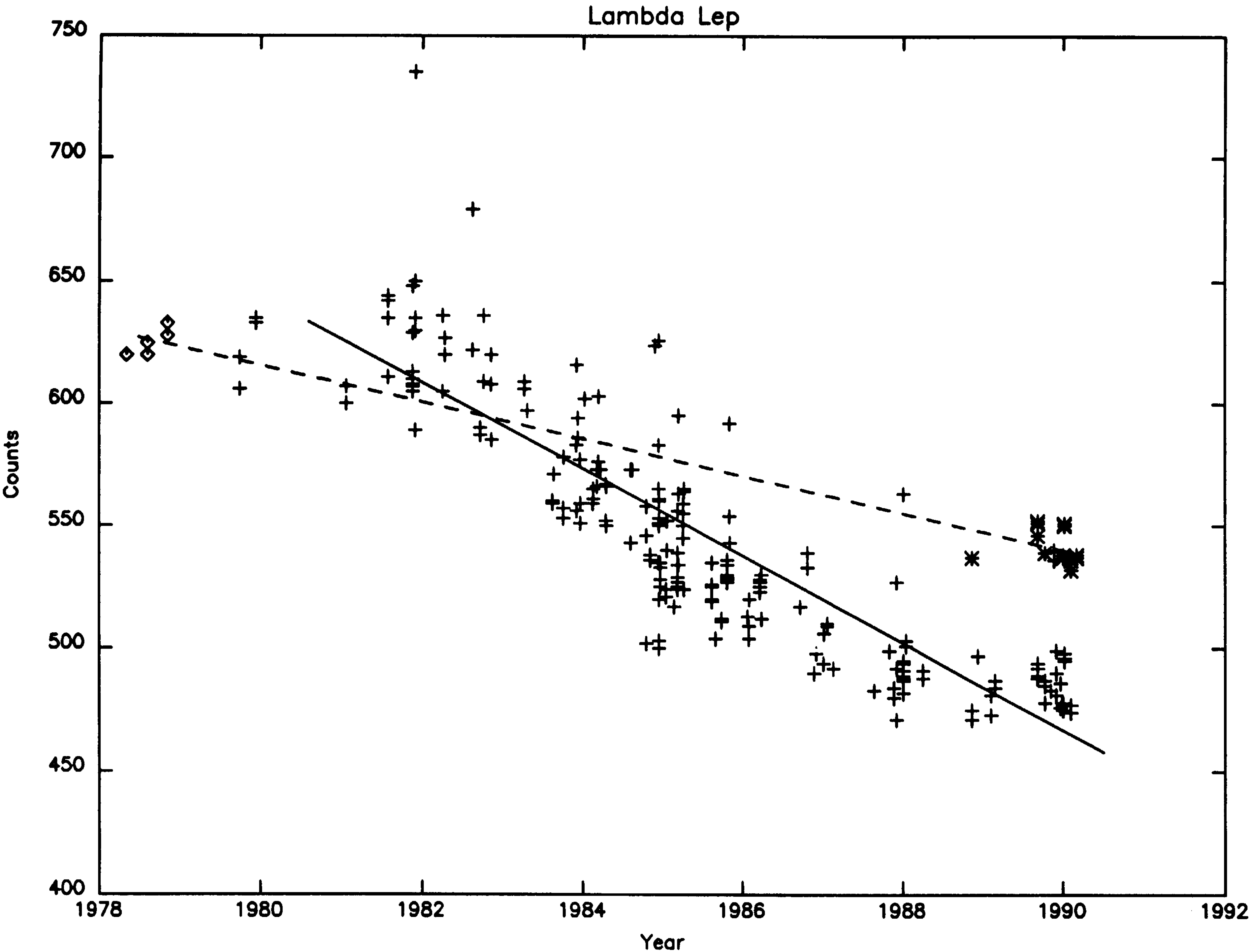

BD +33 2642
Counts
Year
260
240
220
200
180
160
140
120
100
1978
1980
1982
1984
1986
1988
1990
1992

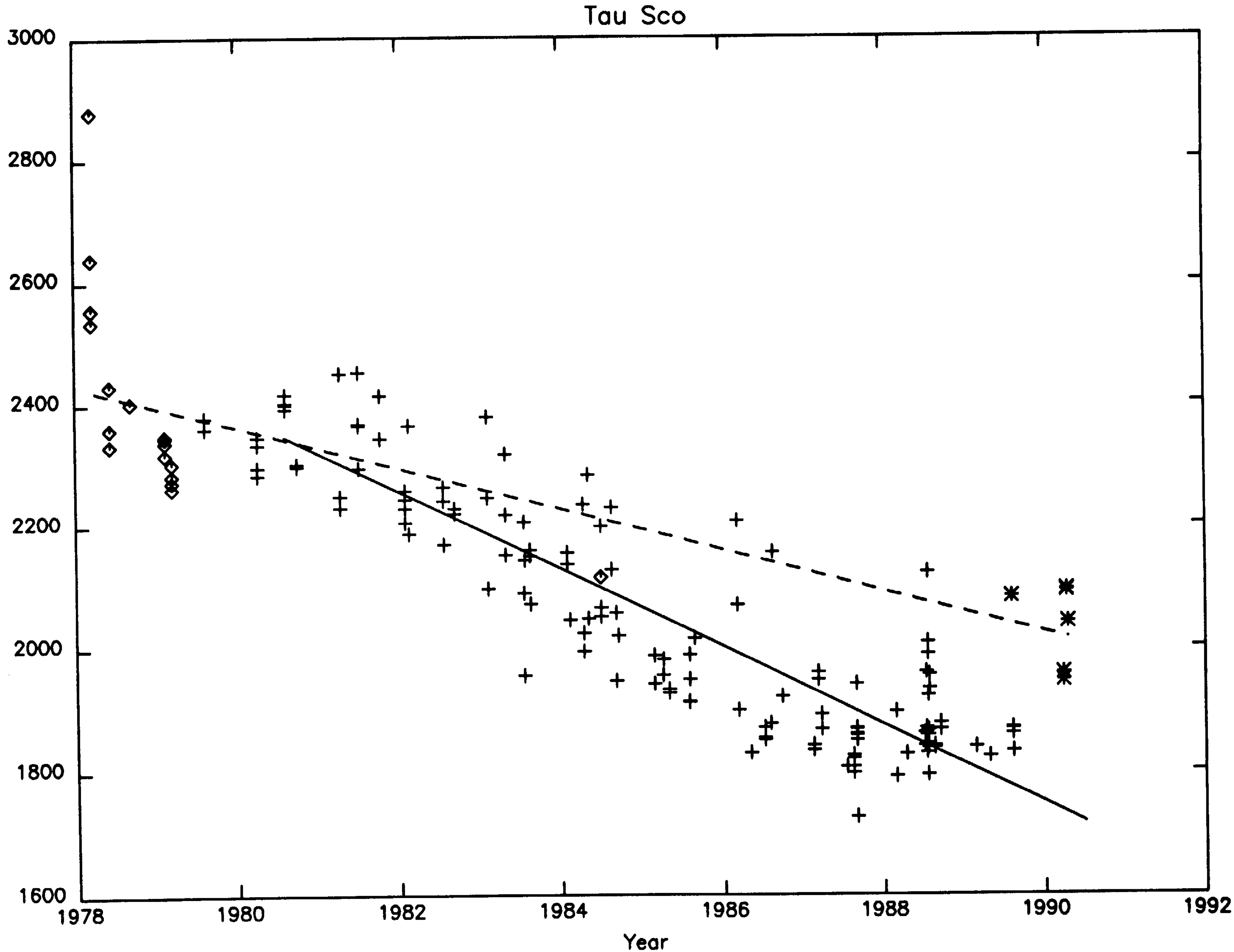
Figure 3



Zeta Cas
1200
1100
1000
900
800
700
Counts
1978
1980
1982
1984
1986
1988
1990
1992
Year

Figure 4


Lambda Lep
750
700
650
600
550
500
450
400
Counts
1978
1980
1982
1984
1986
1988
1990
1992
Year
Figure 5



Tau Sco
3000
2800
2600
2400
2200
2000
1800
1600
Counts
1978
1980
1982
1984
1986
1988
1990
1992
Year

Figure 6