SWIFT-UVOT-CALDB-15-02b
Date Original Submitted: 2010-11-04
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Revision #2
Revised by: A. A. Breeveld
Sections Changed: 3, 4, 6, 8.2 and 9
Comments: Second update – changing **v** filter value

SWIFT UVOT CALDB RELEASE NOTE

SWIFT-UVOT-CALDB-15: Sensitivity loss

0. Summary:

This CALDB product gives a correction for the gradual decline in sensitivity for each filter.

1. Component Files:

FILE NAME	VALID DATE	RELEASE DATE	VERSION

2. Scope of Document:

This document includes a description of the product, expected future updates, warnings for the user, a list of data the product is based on and finally the analysis methods used to create the product.

3. Changes:

This is the second update of the on-orbit calibration for this product. The sensitivity loss in most filters is still consistent with the last version of the calibration, but for **v** filter the value is being changed.

3.1. CALDB file versions:

Version 1 (swusenscorr20041120v001.fits), released on June 30th 2010 contains correction factors for all filters of 1% per year, as described in **SWIFT-UVOT-CALDB-15-01**. It uses a start time for the decline in sensitivity of day 1826 (Jan 1, 2006) for the visual filters and day 1520 (March 1, 2005) for the UV filters.
Version 2 (swusenscorr20041120v002.fits), released on June 6th, 2012, erroneously set the correction factors for all filters to 1.0 (i.e. no correction for decline in sensitivity).
Version 3 (swusenscorr20041120v003.fits), released on January 18th, 2013, corrects

those errors so that the correction factors are as described in this document (Section 9), and the start date for the decline for all filters is December 31st, 2004.

4. Reason For Update:

The **v** filter sensitivity decline is no longer consistent with the 1% per year given for all filters in the previous version. A software issue has been described in section 6.

5. Expected Updates:

The throughput is tested annually and may be updated if changes are seen.

6. Caveat Emptor:

The current default version of UVOTSOURCE makes a correction for the decline in throughput with a factor SENSCORR_FACTOR. However, this is calculated assuming the percentage decline per year (given in section 9) should be used in a compound manner, whereas in this calibration the decline is assumed to be linear. This has little effect on the final correction factor: in the worst case, a source in the v filter in an exposure taken today should be corrected by a factor of 1.121 but UVOTSOURCE will use a factor of 1.128.

7. Data Used:

Several photometric standard sources (see Table 1) have been observed from time to time throughput the mission to check for any changes in throughput. For this report all data up to and including May 2012 have been used.

source	RA	Dec	v	b	u	uvw1	uvm2	uvw2	white
WD1026+453	10 29 45.3	+45 07 03.0	✓	✓	✓	✓	✓	✓	
WD1121+145	11 24 15.9	+14 13 49.0	✓	✓	✓	✓	✓	✓	✓
WD1657+343	16 58 51.3	+34 18 51.0	✓	✓	✓	✓	✓	✓	✓
SA95–42	03 53 43.66	–00 04 33.9	✓	✓	✓				
SA95–102	03 53 07.58	+00 01 10.3	✓	✓	✓				
SA98–646	06 52 02.23	–00 21 16.6	✓	✓	✓				
SA101–278	09 56 54.50	–00 29 39.0	✓	✓	✓				✓
SA101–L3	09 56 54.99	–00 30 24.8	✓	✓	✓				✓
SA104–244	12 42 34.3	–00 45 47.0	✓	✓	✓				✓
SA104–338	12 42 30.3	–00 38 33.0	✓	✓	✓				✓
SA104–367	12 43 59.0	–00 33 30.0	✓	✓	✓				✓
SA104–443	12 42 20.0	–00 25 22.0	✓	✓	✓				✓
SA104–457	12 42 54.2	–00 28 49.0	✓	✓	✓				✓
PG1525–071	15 28 11.60	–07 16 27.0	✓	✓	✓				
PG1633+099	16 35 24.0	+09 47 47.0	✓	✓	✓				
G24–9	20 13 55.68	+06 42 44.9	✓	✓					

Table 1 Standard sources for monitoring throughput.

All the relevant data on these sources were downloaded from the Swift archive at HEASARC. Important keywords in each sky file and also the *uct.hk files were checked for any problems like ‘shift and toss’ loss, which could affect exposure times. However, not all the data had been processed with the same version of uvot2fits and

the keywords were not all available for the earlier versions. The oldest reprocessing of data used here was uvot2fits 3.8 and the most up-to-date was uvot2fits 3.30.

8. Description of Analysis:

For each star, we made region and background files using the 5" aperture for the stars and 27.5 – 35" annulus for the background. We checked each exposure visually for any problems e.g. aspect correction not being applied correctly, or the images being smudged by drift. Where necessary the aspect correction was redone, or where unsuccessful, a special set of region files devised for that particular exposure.

Using UVOTMAGHIST (with LSSfile=CALDB), the fully corrected count rates (and errors) of the sources were extracted for each exposure and written into an excel spreadsheet. Both the co-incidence corrected count rates and those with LSS correction were recorded. Weighted means were calculated for those cases where there was more than one extension, i.e. when several exposures were taken on the same day. The LSS corrected count rates were used in the fits and plots.

The count rates were normalised using the mean count rate for each star in each filter in exposures taken within the first 500 days. For one star which was not observed until day ~800, a factor taken from the fit was used to correct the starting value. This allows all stars to be plotted and fitted together, with the expected value for the beginning of the mission for each star being 1.0. Standard stars only observed at the beginning on the mission, and not re-visited, have not been included.

These normalised plots, for each filter, are shown in Figure 1 to Figure 7.

In each case the data have been fitted with a weighted straight-line fit, shown in the plots. The slopes for all filters are similar to each other except the white filter, but the white filter suffers from more scatter than the other filters. The numbers are shown in Table 2.

Filter	**% loss per year**
V	1.55 ± 0.11
B	0.91 ± 0.10
U	0.90 ± 0.14
UVW1	1.12 ± 0.21
UVM2	1.03 ± 0.22
UVW2	1.08 ± 0.21
White	1.38 ± 0.17
White (bkgnd corrected, see section 8.1)	1.11 ± 0.17

Table 2 The observed change in throughput per year for each filter.

8.1. White filter:

There is a large scatter in the white plot (Figure 7), some of which can be attributed to high background count rates, i.e. the failure of the coincidence correction to cope with high backgrounds. This is illustrated in Figure 8 where the measured count rate of

WD1121+145 is plotted against background count rate. Only the white filter suffers from backgrounds high enough to cause a problem.

Using data for WD1121+145 the counts with higher backgrounds can be corrected using the formula:
$corrcts = cts - m \times bkgnd$, where $m = -120$ and $cts = 181$
For WD1657+343 the gradient m is –151 and the measured decline as a proportion of the true count rate is the same for both WD1657+343 and WD1121+145. Therefore we assume a correction can be applied to all the **white** measurements. The equation is:

$$Truects = \frac{Meascts}{1 - 0.67 \times bkgnd}$$

Since the background is not necessarily the same for all the exposures taken on one day, these points have not been averaged in every case. The corrected plot is shown in Figure 9, and the rate of sensitivity loss is –1.11 ± 0.17% per year. The scatter is reduced and the gradient is now consistent with the other filters.

9. Choice of parameter values:

It is likely that the sensitivity of all filters will decline at the same rate, as most of the decline will be due to the MCPs. In Table 2 all the optical and UV loss rates apart from **v** are consistent with –1.0% per year, and indeed if all the values (except **v**) are averaged the result is –1.03 ± 0.09 % per year . With the background correction, the decline in white is also consistent with –1.0% per year. Thus we chose to set all the values to –1.0% per year for this product, except **v** which is set to –1.5%.

The decline is determined starting from 1st Jan 2005, so this should be the starting date for the CALDB.

10. Figures:

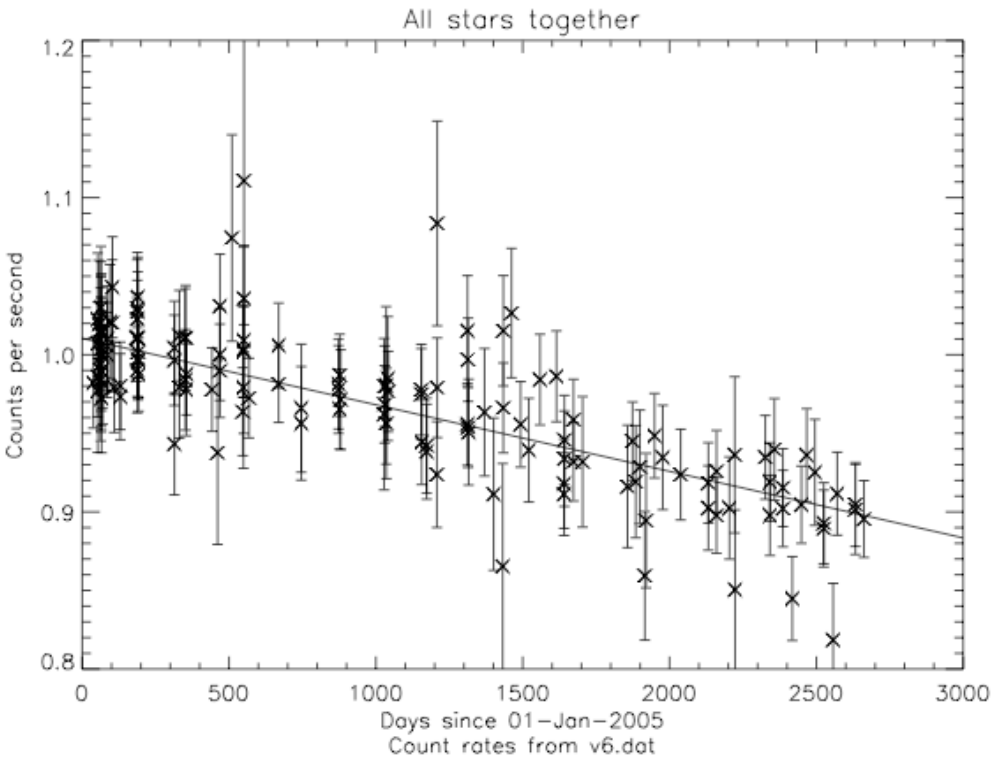

*Figure 1 Count rates of standard stars in **v** filter, normalised to the count rates within the first 500 days post launch, against days since launch.*

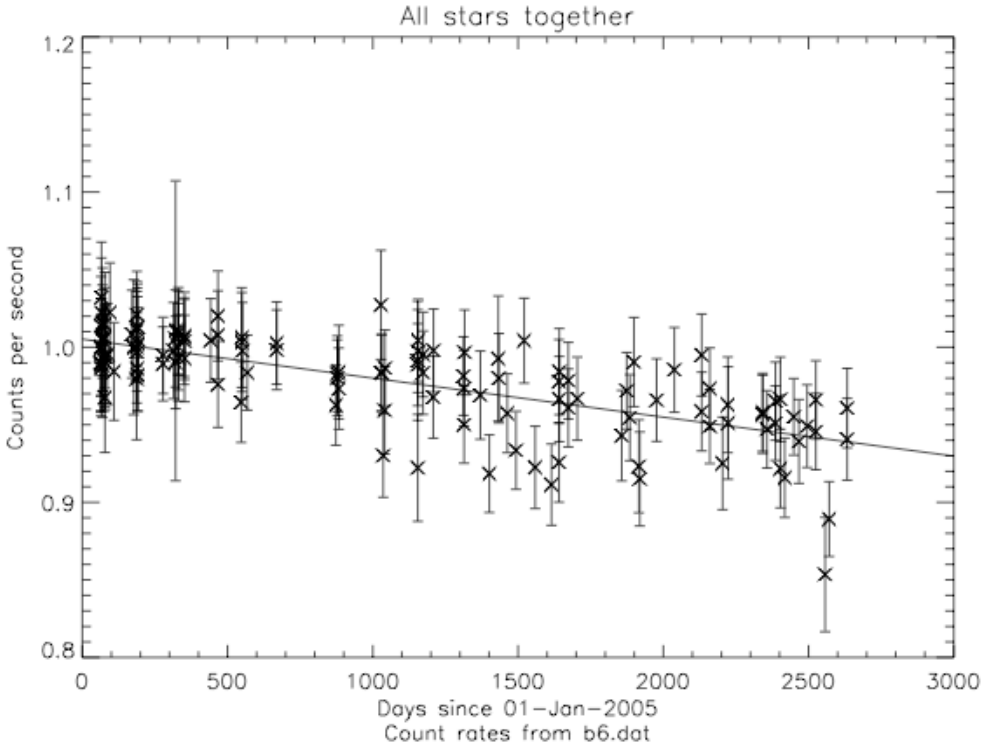

*Figure 2 Count rates of standard stars in **b** filter, normalised to the count rates within the first 500 days post launch, against days since launch.*

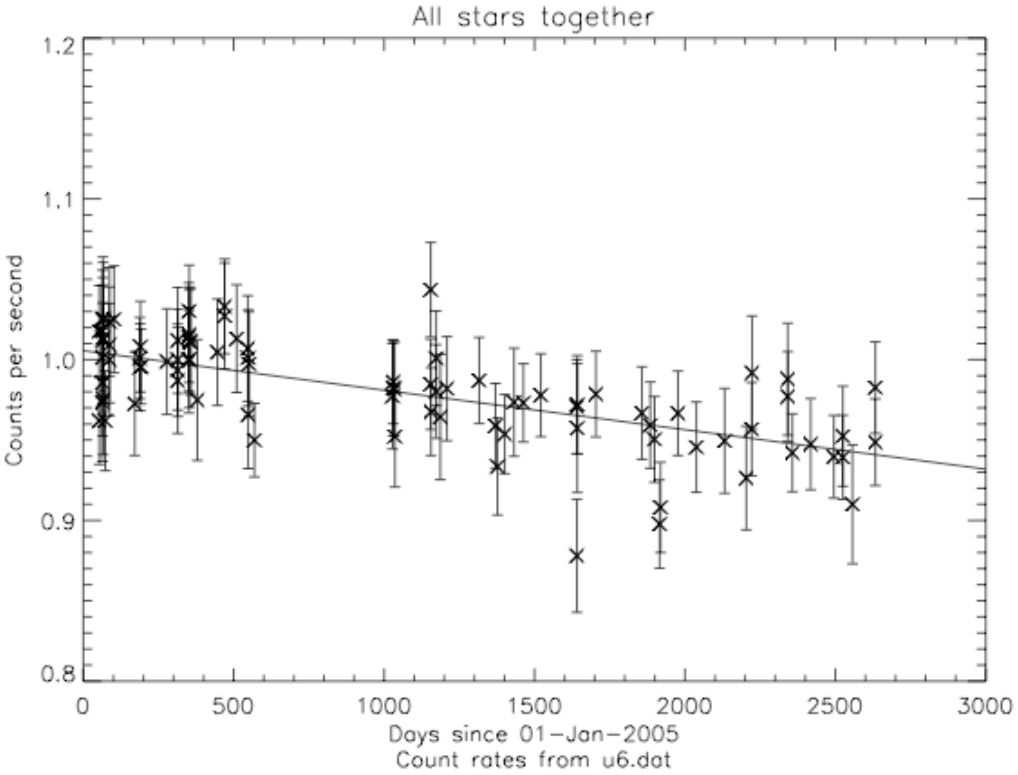

*Figure 3 Count rates of standard stars in **u** filter, normalised to the count rates within the first 500 days post launch, against days since launch.*

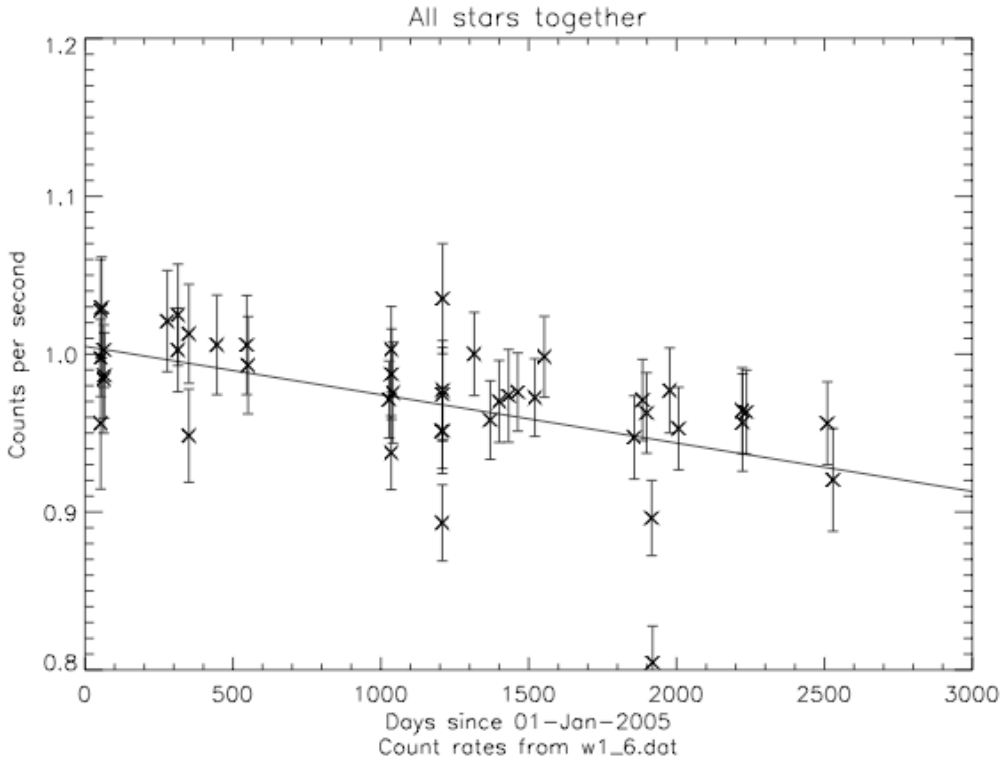

*Figure 4 Count rates of standard stars in **uvw1** filter, normalised to the count rates within the first 500 days post launch, against days since launch.*

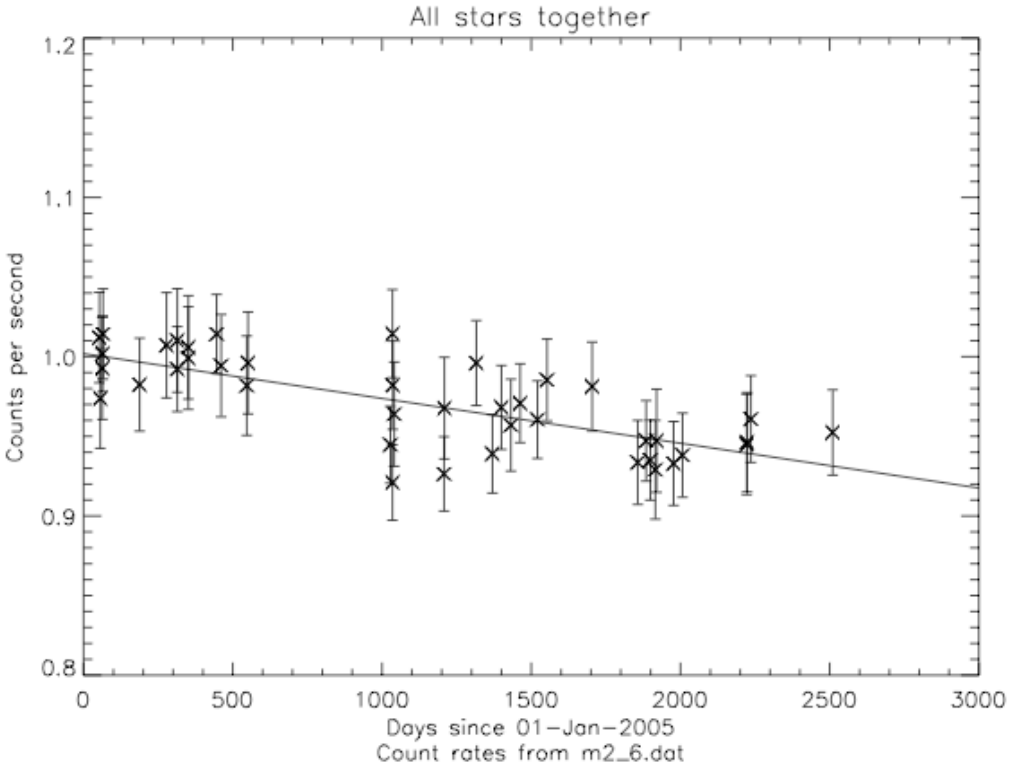

*Figure 5 Count rates of standard stars in **uvm2** filter, normalised to the count rates within the first 500 days post launch, against days since launch.*

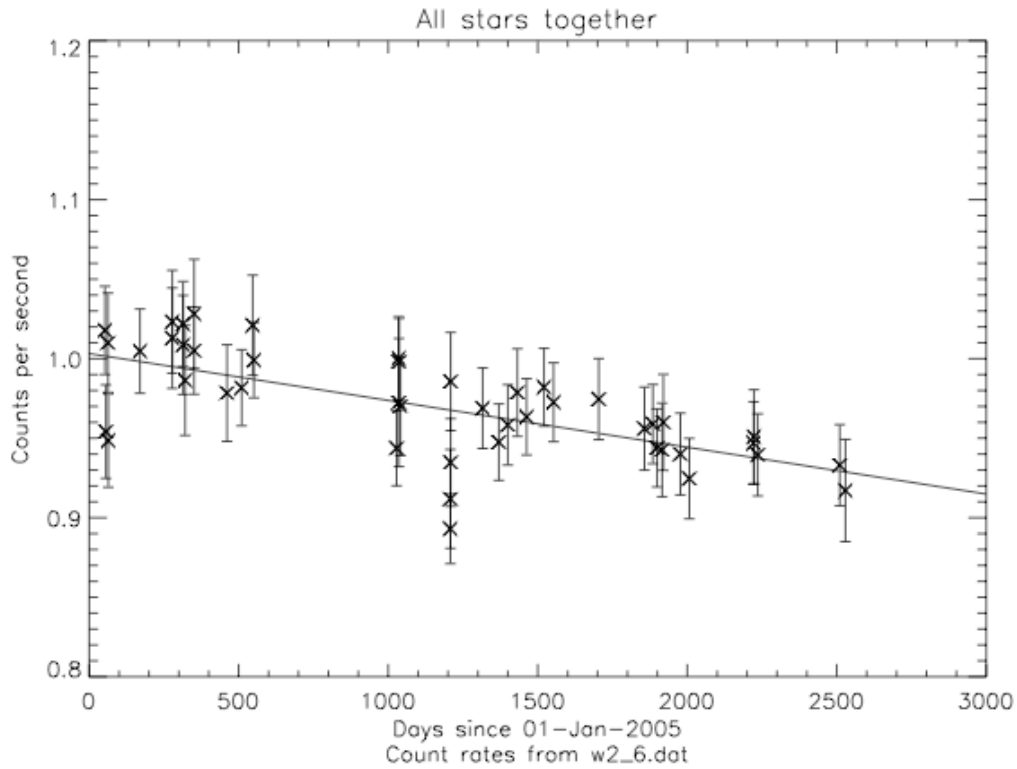

*Figure 6 Count rates of standard stars in **uvw2** filter, normalised to the count rates within the first 500 days post launch, against days since launch.*

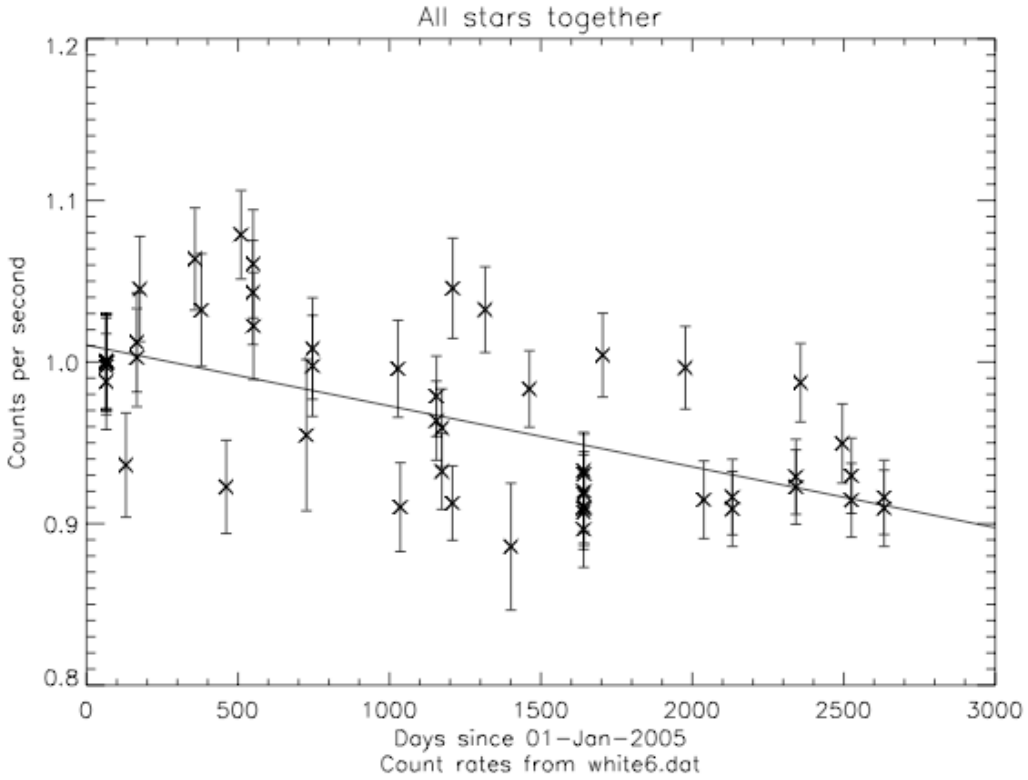

*Figure 7 Count rates of standard stars in **white** filter, normalised to the count rates within the first 500 days post launch, against days since launch.*

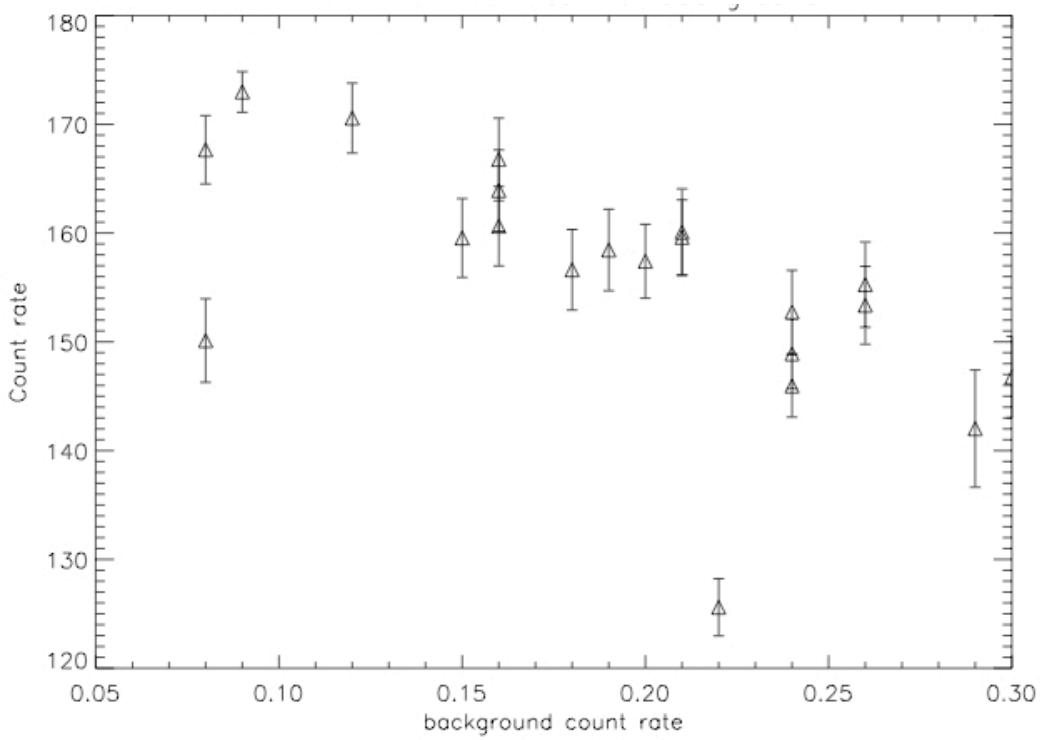

*Figure 8 showing how count rates in the **white** filter in WD1121+145 are significantly affected by the background level.*

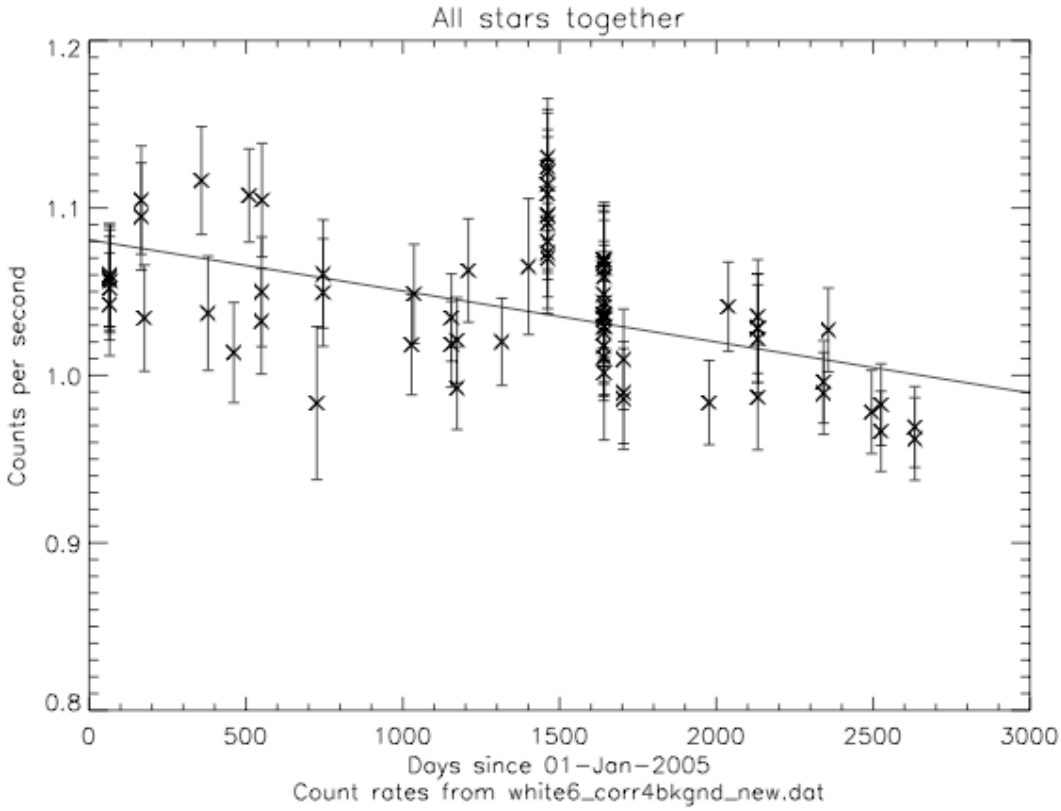

Figure 9 ***White*** *data corrected for background count rate.*