Deadtime Effects in the PCA

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Abstract

This document summarizes our knowledge of deadtime processes in the RXTE PCA. The discussion is broken down into a discussion of deadtime for faint (less than a few Crab) and bright sources. Examples are drawn from the public data. Faint sources experience deadtime of $1-3\%$ due to variations in the observed particle rate; there is an additional deadtime of $\sim 3\%$ for the Crab. The situation is more complex for bright sources where the number of accidentally rejected photons (due to coincidental pile up) becomes significant. A postscript version is available.

1 Deadtime corrections for bright sources: 1-15-98

A deadtime model for bright sources was presented at the "Active X-ray Sky" symposium in Rome, October, 1998. Our contibution to the proceedings of that meeting is available from astro-ph/9712340.

2 Deadtime corrections for faint sources: 9-27-96

For the purposes of this discussion, a faint source is one where the deadtime correction is less than 10%. This includes the Crab. Dead time is produced by all events within the detector, and can be estimated from either Standard1 or Standard2 data. Both standard modes are designed to count each event presented to the EDS once. We illustrate this with data obtained while observing the Crab recently.

Figure 1 shows the total good rate (sum of the 5 rates from the individual detectors), the remaining counts rate, the propane rate, and the very large event rate. The data are collected into 8 second bins. The total rate is modulated by occulted periods, and is $\sim 13,000$ count/sec when on source. The remaining count rate is modulated at twice the orbital period (and is correlated with earth latitude, McIlwain L, or rigidity); in addition there is a contribution to the remaining count rate due to the source itself. This represents chance 2-fold coincidences of X-rays from the Crab. The rate of propane and very large events are also shown. All rates are summed over 5 detectors.

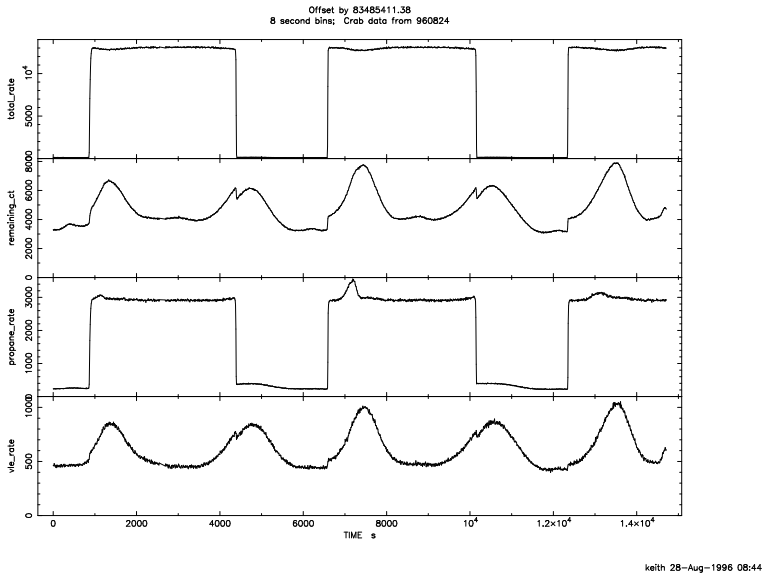

Figure 1: Rates from Standard 1 data in 8 second bins. All detector activity passed to EDS is ocunted in one of these rates exactly once.

Figure 2 shows the estimated deadtime due to each class of event. In this example we assume that the counts are equally distributed between all 5 detectors. The deadtime for any event which triggers the analog to digital converter is $\sim 10\mu$s , so the deadtime induced from the first 3 rates is just rate $\times\ 1.0 \times 10^{-5}$ sec/5., where the factor of 5 gives the approximate rate in each detector.

Figure 3 and 4 give the total rate (repeated from the earlier figure), the estimated total dead time, and the corrected total rate. The deadtime is estimated as the straight sum of the 4 terms above; no cross terms are included. The corrected rate is calculated as total/(1-deadtime). The 2 figures are identical except for the vertical axes. The simple prescription has removed most of the apparent variation in the rates observed from the Crab.

Deadtime corrections similar to this example will need to be performed for all observations attempting to measure relative flux variations to better than a few per cent. The time scales for background induced variation are about 45 minutes (half an orbit) although source variability can cause variations in the deadtime on much faster time scales.

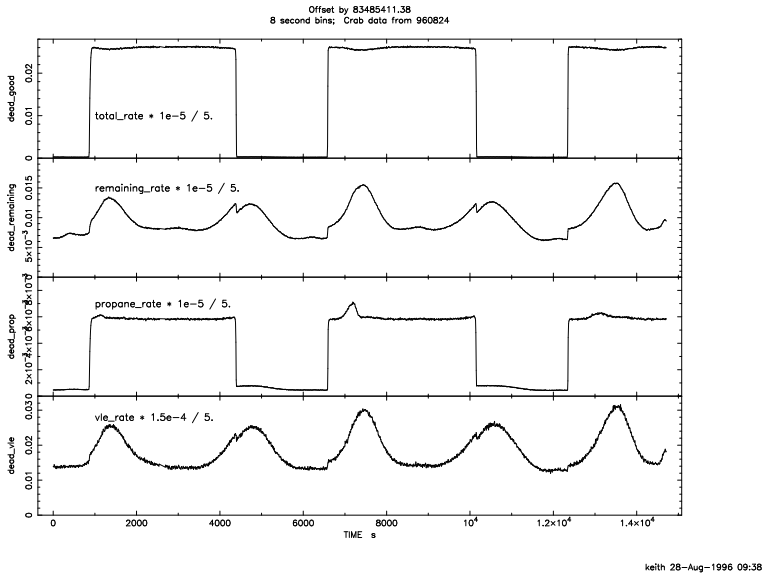

Figure 2: Deadtime, per detector, associated with the rates from fig 1.

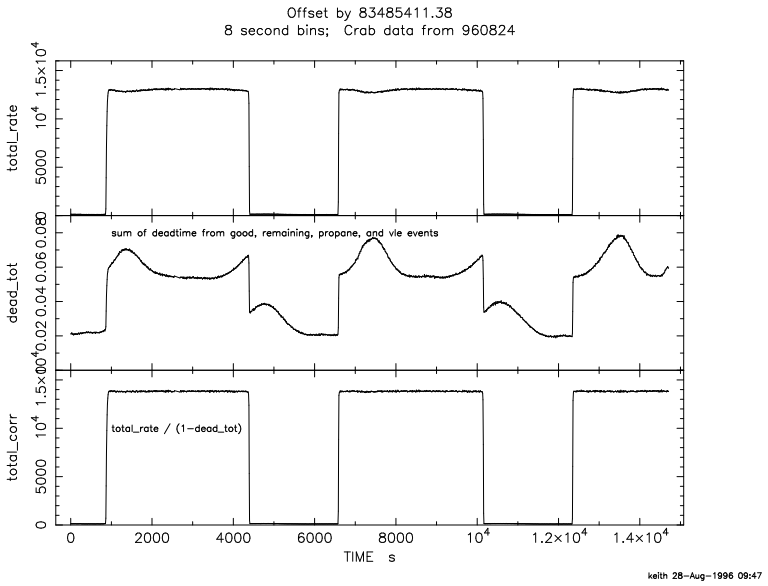

Figure 3: Rate, total deadtime, and deadtime corrected rate for Crab.

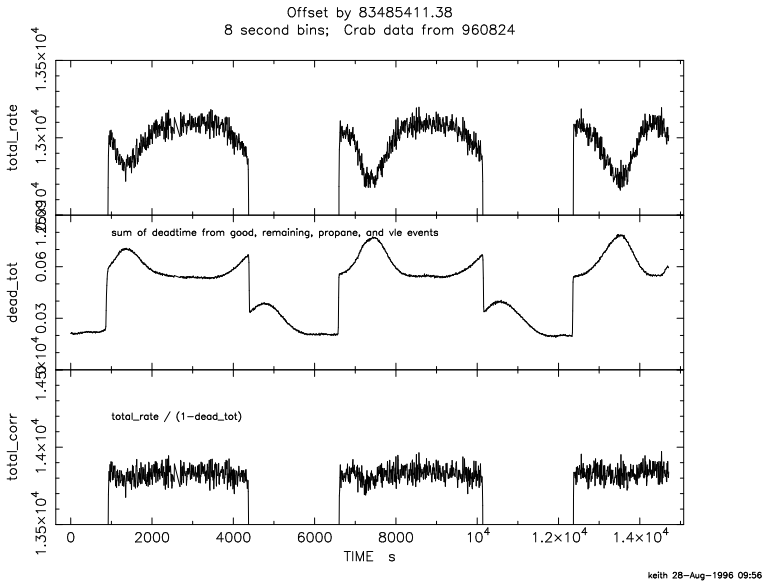

Figure 4: Rate, total deadtime, and deadtime corrected rate for Crab, expanded vertical scale

2.1 Should I correct the estimated background spectra for deadtime?: 10-3-96

We are not sure! For faint sources, the deadtime is dominated by the coincidence rate and not the source rate. Since the primary background model (the Q6 model) is parameterized in terms of background rates, the estimated spectra are likely to come from periods of similar overall deadtime. No correction is made for deadtime in the pcabackest spectra. We tentativley conclude that any deadtime correction applied to the data should also be applied to the estimated background. This conclusion has not been tested so far as we are aware.