Who should correct PCAbackest for PCA deadtime?

Mike Stark, Keith Jahoda
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Abstract

This document summarizes our opinions about who should correct for deadtime processes in the PCA, with particular emphasis on the estimated backgrounds that are produced by PCAbackest. Readers are assumed to be familiar with the discussion of how to correct source data for deadtime effects. A postscript version of this document is available.

1 Reasons to correct PCA data for deadtime

There are many scientific projects that can be approached with PCA data which deserve a careful consideration of deadtime. We present a list (certainly incomplete) of types of project and our opinions about the proper use of deadtime correction for both the PCA data and the estimated background. Users should regard this as the beginning of a discussion rather than an absolute prescription.

Faint Sources - Spectra

There is a deadtime of a few percent ($\leq 3\%$) in the PCA data, even when observing the faintest sources. This arises due to the coincident events and very large events, which are screened out by the EDS good event logic but which none the less create instrument deadtime. For observers who are interested in spectra of faint sources, there is no need to correct the data or background estimate for deadtime. (Our knowledge of the the absolute normalization is uncertain to at least this level). Our definition of *faint* is operational; all sources for which the deadtime attributable to source counts is substantially less than the deadtime due to all other sources are faint. For the Crab pulsar plus nebula the two contributions are about equal.

Since all of the particle related events, which dominate the deadtime, track the VLE rate, the VLE rate is a good predictor of deadtime so long as the source related component is small. The production of the model used by PCAbackest makes no correction for deadtime. However, since the dominant background component is based on a particle related rate, we automatically select a background model with very similar deadtime to the period we are modelling. The model was created from earth looking data, and we are examining the distribution of VLE rates for earth looking data to make sure that this is similar to the distribution of VLE rates for sky looking data.

Faint Sources - Monitoring

Observers who are performing monitoring observations will want to compare each observation to subsequent observations with the highest possible precision. Since many of the monitoring campaigns consist of 1000 second snapshots, which is short compared to the time scale of background observations (i.e. orbital time scales), and because the scheduler may have placed some observations at high deadtime parts of the orbit ($\sim 3\%$) and some at low deadtime parts of the orbits ($\sim 1\%$), it will be desirable to compute the deadtime for each observation using the standard prescription. In this case, once the data are corrected by a multiplicative factor $((1.0 - t_d)^{-1}$, the estimated background should be corrected by the same factor.

High Rate Data - Timing

Bright variable sources may exhibit statistically significant variability on all time scales. Deadtime processes serve to reduce the apparent variability, since an increase in the source counting rate, and simultaneous increase in the instrument deadtime, cause the observed increase in count rate to be less than would be observed for the perfect (zero deadtime detector). (van der Klis et al. 1996, ApJLett 469. L1). Deadtime corrections can be made with a time resolution equal to the time resolution of the good event data by taking the total event rates from either the Standard1 or Standard2 data and the Good Event rate from the source data (binned, event, single bit). This *assumes* that the coincidence rates are not affected by the good event rate. This assumption is violated by the very brightest sources (van der Klis et al. 1996, ApJLett 469. L1) when the rate of double LLD events has a significant contribution from source related events. The timing window during which distinct events on the L1 and R1 chains are passed as a single event is about 4.5 micro-sec (Jahoda et al., 1996, SPIE 2808, p 59). This allows an estimate of the dual flagged rate.

High Rate Data - Spectra

Our advice here is perhaps the least complete. By our own definition, high rate means that the source counting rate is a significant contributor to the deadtime. In this case, the measured VLE rate is affected by the source counting rate in two ways: (a) the source may produce cosmic photons which trigger the VLE, increasing the measured VLE rate; and (b) the source photons create deadtime, which reduces the observed counting rate for all types of events, including VLE events. This may cause PCAbackest to choose a background spectrum which corresponds to a lower overall particle rate (lower VLE rate) than is appropriate for the data, since the measured VLE will be somewhat less than the intrinsic VLE rate. Note, however, that if the VLE rate is 10% too low, this does not imply that the predicted background rate is similarly low, as the slope of the X-ray vs VLE rate curve must be accounted for. For this situation, we give an approximate solution, which should be considered temporary while we work out a more rigourous approach. Since the observed rate is expected to be nearly zero on the third layer below 8 keV, and on all layers above 70 keV (due to the very low efficiency in all cases), we can scale the predicted background so that these conditions are met.