EDIE (Energy Dependant Instrumental Effect) and a Bouncing Baseline

June 15, 2001
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This note will attempt to estimate the size of the baseline shift corresponding to the peak of the wiggle seen in the Auto Correlation Function (ACF) and Time Difference Plots (TDP).

Suppose an autocorrelation function is made, only using the $N\gamma$ xrays that are between E_L where the density of xrays is $\rho(E_L)$ [xrays/kev], and E_H where the density of xrays is $\rho(E_H)$ [xrays/kev]. Suppose the baseline changes by δE. Then at the low edge of the energy range $\rho(E_L)^* \delta E(\Delta t)$ xrays will be boosted into the range, and at the high edge $\rho(E_L)^* \delta E(\Delta t)$ xrays will be boosted out of the range. Thus the fraction change of the number of xrays in the range will be:

$$\Delta Frac = [\rho(E_L) - \rho(E_H)] * \delta E / N\gamma$$

Not all the xrays in the range have the same baseline shift. Consider only those xrays which have come Δt after a previous one. All these xrays share a common baseline shift $\delta E(\Delta t)$. Assume that:

$$[\rho(E_L,\Delta t) - \rho(E_H,\Delta t)] \ / \ N\gamma(\Delta t) \quad \text{(just using xrays in a bin that is } \Delta t \text{ after a prior xray)}$$
$$=$$
$$[\rho(E_L) - \rho(E_H)] \ / \ N\gamma \quad \text{(using all xrays in the range)}$$

Then the fractional change of the number of these xrays with ΔT spacing will be the same $\Delta Frac$ calculated above.

If sufficiently small ACF time bins are chosen, such that there are only 0 or 1 xrays per time bin of the original xray time series, then the ACF just counts the number of xrays for a particular bin width and time after the last xray. The fractional change in this ACF bin is equal to $\Delta Frac$. Therefore:

$$[\Delta ACF / ACF] = [\rho(E_L) - \rho(E_H)] * \delta E / N\gamma$$

$$\delta E(\Delta t) = [\Delta ACF / ACF] * N\gamma \ / \ [\rho(E_L) - \rho(E_H)]$$

Another way to see the EDIE effect is to make the time difference plot for xrays between E_L and E_H, and to compare it to the Poisson prediction. Then for a particular bin of the TDP:

$$\delta E(\Delta t) = [\Delta TDP / TDP] * N\gamma \ / \ [\rho(E_L) - \rho(E_H)]$$

The following pages show the analysis of some USA Fe^{55} ground data. When only energy channel 6 is used, the EDIE wiggle is seen in both the ACF and TDP. Using the above formulas yields a maximum baseline shift (upward) of ~9 ev for xrays which come ~.4 msec after a prior one. At the ADC I think 10 V ~ 15 kev. Therefore the 9 ev corresponds to a baseline shift of ~6 mV at the ADC.

Study EDIE (Energy Dependant Instrumental Effect)

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D:\Winmcad\Usa\Edie.mcd

Ground USA Fe55 (mode 2) Fe55 data H:\Usadata_old_analysis_from_C\fe55\gnd246_1.dat which has the first 600000 lines from USA_2_Y1997_D246_084750_D246_085807.FILT made by KC

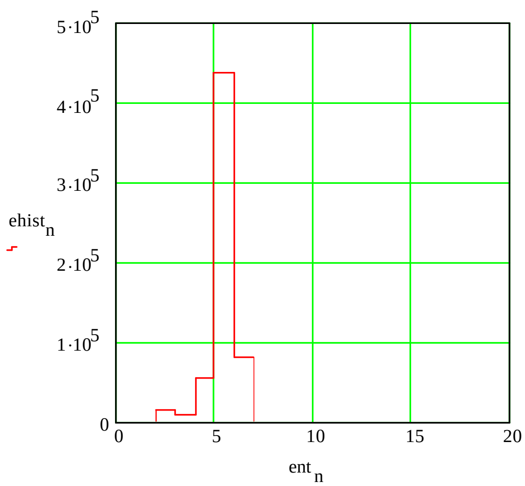
data := READPRN(datafile)   datafile ≡ "H:\USAdata_old_analysis_from_C\Fe55\Gnd246_1.dat"

$istart := 1$ $pha := data^{\langle 2 \rangle}$ $jcols := cols(data)$ $j := 0 .. jcols - 1$

Make the pulse height distribution

Histogram the times $nbins := 20$ $n := 0 .. nbins - 1$ $ebinsize := 1$ $ent_0 := -.00001$ $ent_{n+1} := ent_n + ebinsize$

$ehist := hist(ent, pha)$



[pha chan]

$$cut(data) := \begin{array}{|l} i \leftarrow -1 \\ \text{for } n \in istart .. rows(data) - 1 \\ \quad \text{if } (data_{n,2} = 6) \\ \quad\quad \begin{array}{|l} i \leftarrow i + 1 \\ \text{for } jcol \in 0 .. 4 \\ \quad d_{i,jcol} \leftarrow data_{n,jcol} \end{array} \\ d \end{array}$$

$$monotonic(t) := \begin{array}{|l} i \leftarrow 0 \\ x_0 \leftarrow t_0 \\ \text{for } n \in 1 .. length(t) - 1 \\ \quad \text{if } t_n \geq x_i \\ \quad\quad \begin{array}{|l} i \leftarrow i + 1 \\ x_i \leftarrow t_n \end{array} \\ x \end{array}$$

Cut on the energy spectrum (only use bin 6):

$d := cut(data)$ $irows := rows(d)$ $i := 0 .. (irows - 1)$

$t_i := 10^{-6} \cdot round\left[\left(d_{i,1} - d_{0,1}\right) \cdot 10^6\right]$ $length(t) = 79547$

$t := monotonic(t)$ $length(t) = 79085$ $N\gamma := length(t)$

$kmax := length(t) - 1$ $k := 1 .. kmax$ $kmax = 79084$

$tmax := t_{kmax}$ $tmax = 145.410922$

Histogram the time difference

$kkmax := floor(kmax \cdot .99)$ $kkmax = 78293$ $kk := 1 .. kkmax$ $ttbinsize := .000064$ $nn := 0 .. 300$ $dnt_0 := -.0000001$

$dnt_{nn+1} := dnt_{nn} + ttbinsize$ $tdiff_{kk} := t_{kk} - t_{kk-1}$ $tdiffhist := hist(dnt, tdiff)$

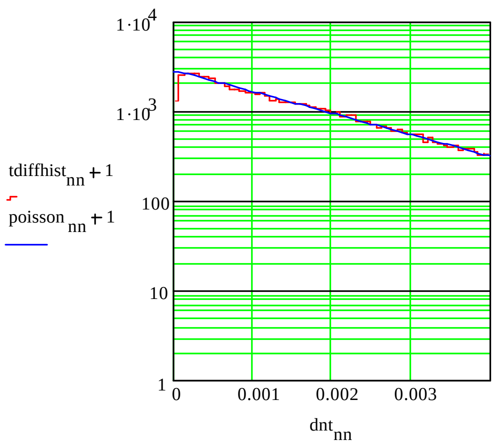
$t_{kkmax} = 143.934$ [sec] $rseen := \frac{kkmax + 1}{t_{kkmax}}$ $\tau := .000022$ [sec] $rveto := 0$

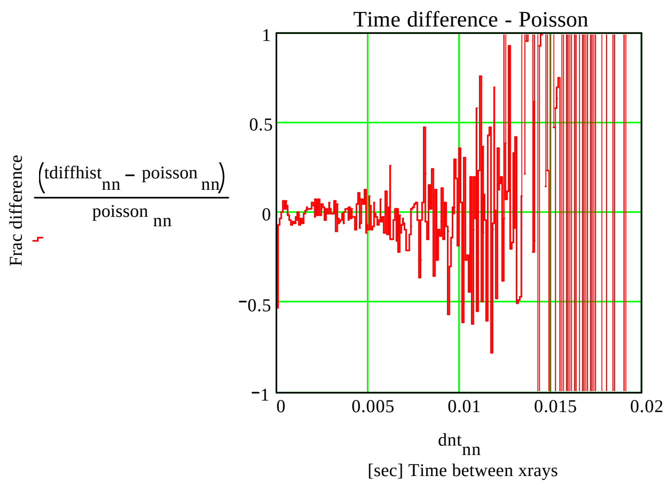
$rseen = 544$ [Hz]

Expected curve for a Poisson souce

$$probGary(n, rseen, rveto, \tau, tbin) := \left| \begin{array}{l} \rho \leftarrow \frac{rseen \cdot (1 + rveto \cdot \tau)}{1 - rseen \cdot \tau} \\ p \leftarrow \rho \cdot tbin \cdot e^{-\rho \cdot (n \cdot tbin - \tau)} \\ p \end{array} \right.$$

$poisson_{nn} := kkmax \cdot probGary(nn, rseen, rveto, \tau, ttbinsize)$

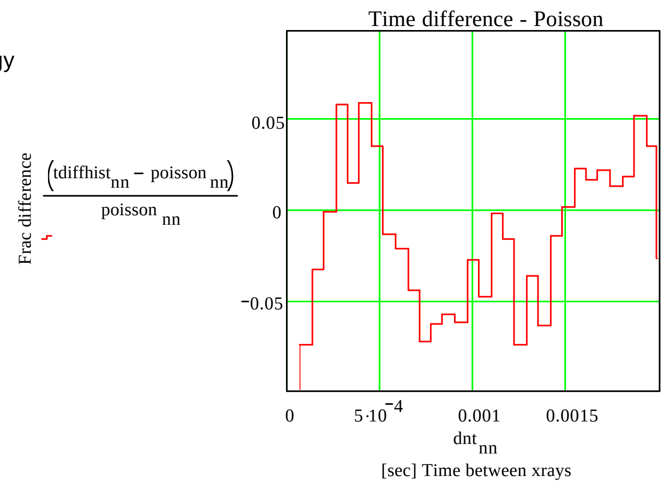




The fractional change in the Time Difference plot at .4 msec is ~.04 . This corresponds to the same fractional change of the number of xrays in the cut energy region. Assume this fractional change is caused by a baseline shift. The density of xrays at the lower and upper energy cuts are 4.4*10^5 and .8*10^5 [xrays/kev] respectively. Nγ is the total number of xrays in the cut region. Therefore, the baseline shift (at .4 msec) is:

$$\delta E := \frac{.04 \cdot N\gamma}{(4.4 - .8) \cdot 10^5}$$

$\delta E = 0.0088$ [kev]



Histogram the times

$nbins := 2^{20}$ $\qquad nbins = 1.049 \cdot 10^6 \qquad n := 0..\, nbins - 1 \qquad jnt_0 := 0.$

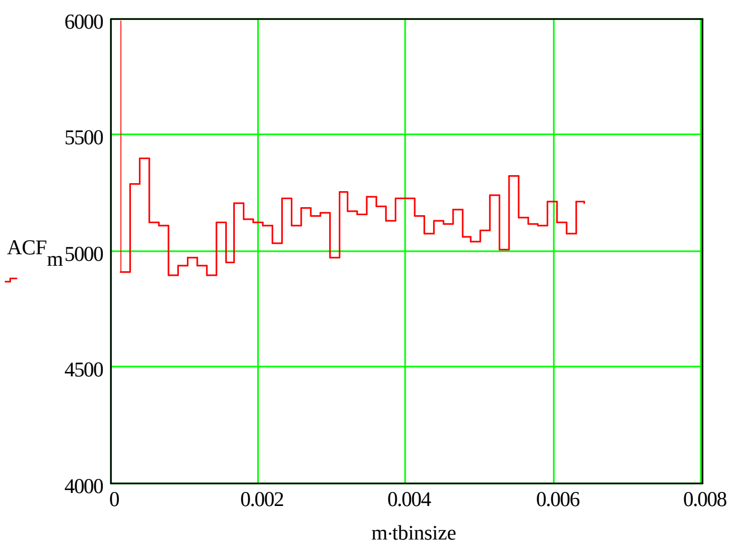
$tbinsize := .000128 \qquad jnt_{n+1} := jnt_n + tbinsize$

$thist := hist(jnt, t) \qquad tused := nbins \cdot tbinsize \qquad tused = 134.218$ [sec]

Calculate the Auto Correlation Fuction (ACF):

$mmax := 50 \qquad m := 0..\, mmax$

$$ACF_m := \sum_{p=0}^{nbins - mmax} thist_p \cdot thist_{p+m}$$



The fractional change in the ACF at 3*.128= .4 msec is 200/5150 = .04

This corresponds to the same fractional change of the number of gammas in the cut energy region. This fractional change would be caused by a baseline shift of:

$$\delta E := \frac{.04 \cdot N\gamma}{(4.4 - .8) \cdot 10^5}$$

$\delta E = 0.0088$ [kev]