PrimEx Data Acquisition Rates

12/11/01
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Introduction:

The goal of this document is to describe rate capabilities of the DAQ which will be implemented for PrimEx. In particular, what we might expect for deadtime and event rates.

Based on earlier trigger simulation studies, the trigger rate expected, under ideal conditions, is less than 30Hz with a 100% trigger efficiency. It is assumed we can always lower the discriminator thresholds to increase the event rate and regain any efficiency lost due to the "less than ideal" conditions of the actual experiment. This being the case, we are then limited by what is considered an acceptable deadtime. For PrimEx, we need a very low deadtime in order to achieve the statistical goals of the experiment with the beam time awarded.

DAQ rate limitations:

There are three places which might limit the DAQ rate:

1. **Conversion**: The digitization time taken by the fastbus module
2. **Readout**: The time it takes to read the data into the ReadOut Controller (ROC)
3. **Transfer**: The time it takes to transfer the data from the ROC to the host Unix system over the ethernet.

Each of these is now discussed below. We'll assume a 2 kHz DAQ rate and that each T−counter is firing at 2MHz where needed.

Conversion Time:

The conversion times for the three types of Fastbus modules which will be used in the PrimEx DAQ are given in the table below.

We will use one 1877 TDC module for HYCAL and a number of them for the tagger E−counters. The tagger also uses an 1877S and two 1872A's for the T−counters.

The 1872A TDC's are used for the high resolution timing of the left and right PMTs of the tagger T−counters. They have a full range of 820ns. The number of hits a single T−counter will see per event is given by: $1-e^{(-820ns*2MHz)}=0.8$. This gives a total conversion time for each of the 1872A TDCS of

$0.8*61 channels*2.5\mu s+10\mu s=132\mu s$.

Fastbus Module	***Conversion Time***
LRS 1877 TDC	750 nsec + 50 nsec per hit within the programmed full scale; 1.6 μsec minimum
LRS 1877S TDC	1.2 μsec + 50 nsec per hit within the programmed full scale; 1.75 μsec minimum
LRS 1872A TDC	2.5 μsec for each channel that is stopped ("hit") + 10 μsec (taken from LRS 1875A specs.)
LRS 1881M ADC	12 μsec for all 64 channels in 13−bit mode, 9 μsec of all 64 channels in 12−bit mode

The 1877S TDC is used for the tagger T−counter LR coincidence signals and for the pair spectrometer. The maximum, full range is $32\mu s$, but we may need to limit this and/or the number of hits per event in order to maintain a reasonable event size. The number of hits a single T−counter channel will see, on average, in $1\mu s$ is $1\mu s*2MHz=2\,hits$. The total conversion time for the module would then be $1.2\mu s+2*61*50ns=7.3\mu s$. The pair spectrometer rates will be about a factor of 10 smaller than the T−counters so they will not dominate the conversion time of the crate.
The maximum discriminator rate expected from HYCAL is on the order of 50 kHz so it too will be a relatively small conversion time.

The 1881M ADC modules will each have a $12\mu s$ conversion time.

The conversion time of the 1872A modules dominate the total conversion time of all systems in the DAQ. If we were to exclude these high resolution TDCs and rely purely on the 1877's, we'd reduce the total conversion time by a factor of 10 to the $12\mu s$ needed by the 1881M ADC's.

Readout Time:

The CODA/Fastbus system can be run in one of two modes, buffered and un−buffered. The buffered mode takes advantage of the multiple−event buffering available on many Fastbus modules (including all those which we plan to use for PrimEx). When using buffered mode, the Trigger Supervisor is allowed to send another trigger as soon as all modules have completed the conversion phase. Un−buffered mode requires the readout phase to complete before another trigger can be accepted. Since the readout phase can be as long as $200-300\mu s$, deadtime can be significantly reduced using buffered mode.

Using buffered mode, the readout time can still become a factor if the event rate is large enough that the mean time between triggers becomes comparable to the conversion time plus readout time. In a worst case scenario, this would be $132\mu s+300\mu s=432\mu s$. This would correspond to a rate of about 2.3 kHz. Once the buffers gets filled up, the Trigger Supervisor would be forced to wait for the end of the readout phase before taking another event. The deadtime would reflect this condition by suddenly jumping from 30% to 100%.

The important point here is that we will run in unbuffered mode and the readout time will not be a factor. We must only ensure that our event rate is low enough to maintain a reasonable deadtime (<10%).

Transfer Time:

The transfer time is really only a limitation when we approach the 1Gbit ethernet line speed. The JLab online group has stated that this should not be a concern provided we stay at around 1MB/sec or less per fastbus crate. In practice, G6c ran in the summer of 2001 with data rates as high as 8 MB/s from the TAGE crate.

For the ADC's the built–in pedestal suppression will limit the number of 32–bit words per event to less than 100 (each of the two photons hitting the calorimeter will reach at most, about 36 detectors). This will give as an upper limit, $(100\, words/event)(4\, bytes/word)(2000\, events/sec)=800\, bytes/sec$. This rate will be shared between two fastbus crates.

For the T–counter TDC's we assume a $1\mu s$ time range, as above. This gives, on average, 2 hits per counter, per event. The tagger E–counter TDC's reside in the same fastbus crate. Since the E–counters overlap by 1/3, there will be 2 E–counter hits for each T–counter hit 50% of the time and 1 E–counter hit for the other 50% of the time. This gives $2*0.5+1*0.5=1.5$ E–counter hits per T–counter hit on average. The pair spectrometer will contribute

$(4\, paddles/e^+e^-)(0.05\, e^+e^-/\gamma)(1\,\gamma/Tcntr\, hit)=0.2$ p.s. hits/Tcntr hit.

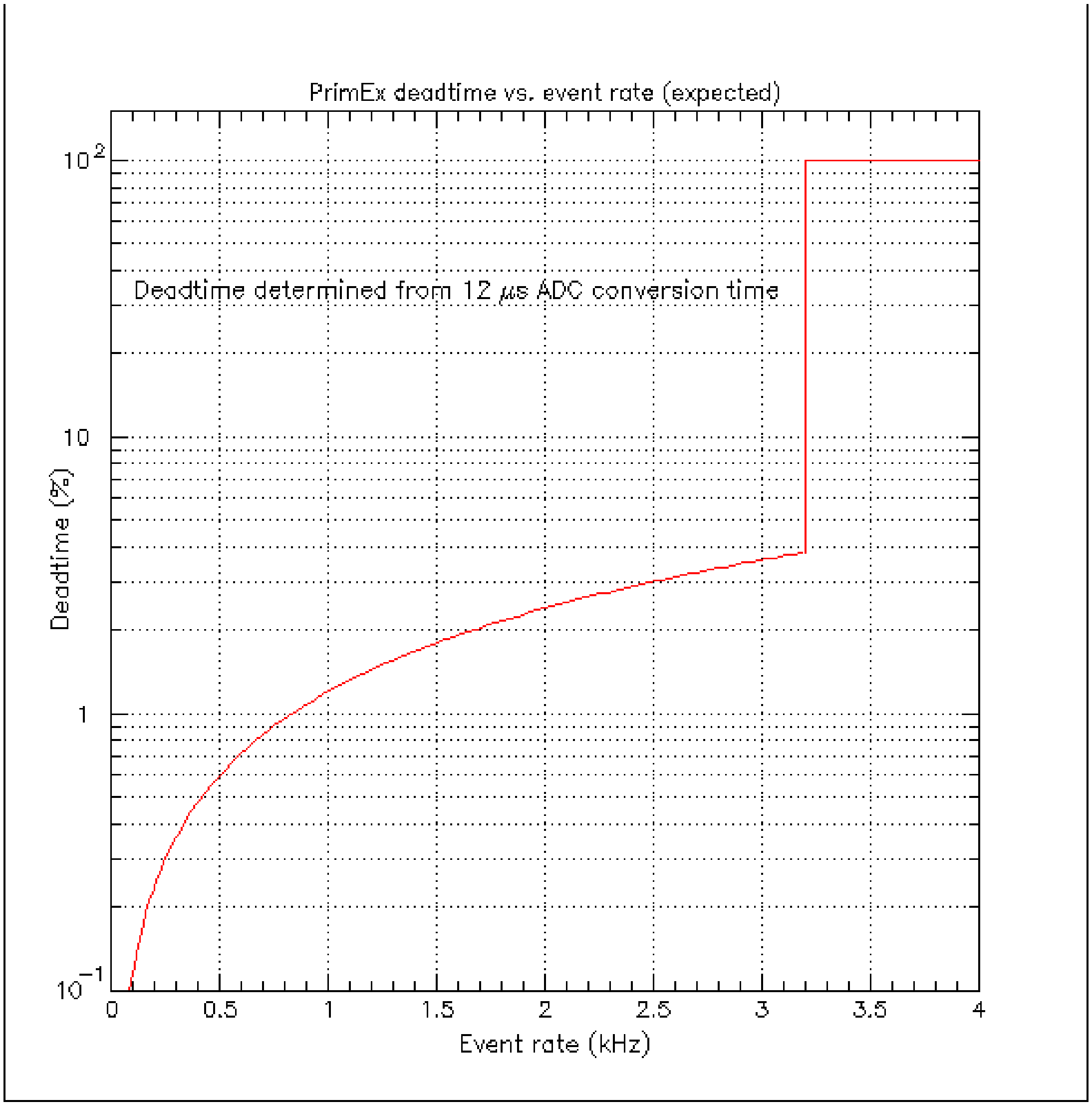
The total data rate for the TAGE crate will then be:

$$\left(2+2*1.5+2*0.2\, hits/Tcntr/evt\right)(61\, Tcntrs)(4\, bytes/hit)(2000\, evt/sec)=2.6MB/sec$$

This rate can always be cut down by turning off part of the tagger's focal plane.

Deadtime:

Using buffered mode, the deadtime will be determined solely by the conversion time of the slowest module. If the high resolution 1872 TDC's are excluded, the module with the longest conversion time is the 1881M ADC. This has a conversion time of $12\mu s$. Using this, the deadtime as a function of rate is a simple linear relation shown in the plot below. The worst–case–scenario cutoff at 3.2 kHz was determined by assuming a $300\mu s$ readout time. Shorter readout times will only push that cutoff to higher event rates.



PrimEx deadtime vs. event rate (expected)
Deadtime determined from 12 μs ADC conversion time
Deadtime (%)
Event rate (kHz)
10^2
10
1
10^-1
0
0.5
1
1.5
2
2.5
3
3.5
4

Conclusions:

- We should, if at all possible, exclude the high precision 1872 TDC modules since their long (and non–constant) conversion time would increase our deadtime by more than a factor of 10.

- Without the 1872 TDC's the deadtime is determined by the 1881M ADCs and should be less than 2% at a 1 kHz event rate.

- Information from the tagger's 1877/1877S multi–hit TDCs will dominate the data stream. The estimates above show that it should be within the limits of the DAQ system's capabitilies which were tested during G6c. This estimate, however, is based on limiting hits to a $1\,\mu s$ range.