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Stefan Anderson  
Susan Burke  
Dan Edmunds  
Cory Fantasia  
Mike Mulhearn

#### Executive Summary:

On 31 October 2005, the latency for Level 1 CalTrack trigger was measured with the L1CalIIb electronics on the CH1 sidewalk and the L1CalTrack electronics in MCH1. This measurement has important consequences for the overall trigger settings in RunIIb because sequence L1Cal-to-L1CalTrack-to-Trigger Framework (TFW) represents the critical path which produces the latest Level 1 Accept (L1A) decision information to arrive at the TFW. Consequently, the timing of this path constrains the setting of the L1A deadline in the TFW in RunIIb. On 3 March 2006 this number was modified to incorporate the changes to Analog Digital Filter (ADF) to Trigger Algorithm Board (TAB) latency. These changes were made to improve the robustness of the link between these two systems. This recent change removed 11ns of latency from the previous 31 October measurement.

The latency of the L1CalTrack L1A was measured to be 287 ns after the L1Muon L1A. The latency of L1Muon was measured to be approximately 85ns before L1A deadline. Combined with the 3300ns L1A deadline length currently used in RunIIa, the absolute latency of L1Muon is approximately 3210ns. These numbers yield an absolute latency for L1CalTrack of 3502ns. This is 202ns greater than the RunIIa L1A deadline.

#### Measurement Details:

Due to transmission errors occurring between the ADF and TAB, the latency between these two systems was increased by 11ns. The latency numbers that follow refer to the 31 October 2005 latency measurement. Those referring to the L1CalTrack latency should be increased by 11ns. The L1Muon latency numbers are unaffected.

The L1CalTrack latency measurement was taken on 31 October 2005. The lag was calculated using the time difference between L1Muon's "Beginning of Turn" (BOT) signal and L1CalTrack's BOT signal. The L1CalTrack BOT arrived 276ns after L1Muon's. To know the absolute latency of L1CalTrack, we needed to measure the time L1Muon's BOT arrives at the TFW before the L1A deadline. A precise measurements was needed to understand the relative latency measurements previously taken. The latency of L1Muon relative to L1A deadline was measured using the time difference between the falling edge of the first pulse (corresponding to the first live bunch crossing) after the sync gap and the L1Muon BOT signal. This value was 3.2 microseconds when measured to the far edge of the BOT, and approximately 15ns larger when measured to the midway point on the slew. This gives an absolute latency of L1Muon of 3215ns (3300 - 85) and an absolute latency of L1CalTrack of 3491ns (3215+276). L1CalTrack arrives 191ns after the RunIIa L1A deadline.

The original specification for RunIIb was to increase the L1A deadline by 6 bunch crossings (1 BC =132 ns). We can now say that such a large change is not needed. 191ns

corresponds to 1.45 BCs, so moving the deadline by at least 2 BCs would accommodate L1CalTrack. However, due to limitations on increasing pipeline depth in some systems it was concluded that the L1A deadline would be increased by 3 BCs.

In its current configuration on the sidewalk, the ADF uses BLS signals coming from the Calorimeter North End Cap. These signals are split in MCH so that data can be read out simultaneously by the I1a and I1b trigger systems. This setup introduces a number of timing factors into the latency measurements that need to be accounted for in order to understand the latency measurement.

When the I1b system is installed, BLS signals from all parts of the Calorimeter will need to be processed by the ADFs, including those from the South End Cap. The cables coming from the South EC are longer than those coming from North EC because those coming from the South must travel the length of the detector. According to Dan Edmunds, the extra length in the cables corresponds to 100ns of delay. So an additional 100ns of latency must be added to the measured minimum latency of the North EC channels to allow for the inclusion of the latest-arriving channels..

Additional latency is introduced into the measurement on the sidewalk based on the location of the splitters. The analog signals from the calorimeter are split in MCH. From there one set goes to the L1CalI1a system and the other set is sent to the sidewalk test stand for the L1CalI1b system. The length of cables from the splitters in MCH to the sidewalk introduces a delay of approximately 100ns. Since the splitters and their cables will be removed when L1CalI1b is installed in MCH1, this 100 ns delay will disappear. When we calculate the overall latency, we subtract this delay, which simply cancels the 100 ns which must be included to accommodate the signals from the South EC. However, as we will not gain back the latency lost to the splitter delay until we move into MCH, by using a minimum latency configuration, we are now unable to use signals from the South EC on the sidewalk.

A previous L1CalTrack latency measurement was taken on 10 October 2005 before the L1CalI1b was configured with its final timing parameters. L1CalTrack's BOT arrived 752ns after the L1Muon BOT. We knew then that the ADFs and TABs contained excess latency. The ADFs and TABs were given this extra latency to allow for more extensive testing on the Sidewalk Test stand than otherwise possible. The L1cal group decided to move the system into a minimum latency configuration corresponding to the timing once the L1CalI1b system is moved into MCH.

This earlier configuration also included latency that was earmarked for additional ADF features. One such feature was designed for purposely sampling the BLS signals late to prove we sample the signal at the correct time. By moving to a minimum latency in ADFs we would be unable to sample the signals late. It also means that the later signals to arrive would have zero delay before they are processed. Another feature which has been limited by latency considerations is the ability to sample the peak of the BLS signals more often than is currently done. More samples might offer better Et resolution on the incoming signals. In moving from this earlier configuration to the final timing, Dan Edmunds reported that the ADF latency was reduced by 321ns.

The TAB's timing had extra time built in to decouple the TAB from the ADF during sidewalk testing. While it is preferable to have this extra time, it was not necessary and was removed. The TABs now begin processing the data from the ADFs as soon as it is available. Mike Mulhearn reported that the TAB latency had been reduced by 158ns in moving to the final timing.

<i>Event</i>	<i>Time after Bunch Crossing</i>
Bunch Crossing	0 ns
RunIIa L1A Deadline	3300 ns
TFW Receives CalTrack BOT (3 March 06)	3502 ns
RunIIa L1A Deadline + 3 Ticks	3696 ns